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ENGINEERING GRADUATE STUDY

By R. W. SORENSEN
Vice-President of the Society

The recent increase in the number of graduate students in engineering colleges indicates that graduate work is at the threshold of a growth which may be so rapid as to introduce programs of curricula and standards infinitely more complicated than were the problems of undergraduate engineering education. Indeed the graduate courses now in operation have already produced unfavorable as well as favorable results. The entire tone of engineering education and the professional status of engineers will be determined very largely by standards set by the graduate schools and the accuracy with which the degrees granted define the ability characteristics of their recipients.

The early establishment of specifications defining standards, acceptable curricula content and degree significance are desirable. Recommendations for the preparation of these specifications are properly within the scope of the S. P. E. E. activities and may well be made a more active part of its program.

Several engineering colleges now annually have graduate classes of a dozen or more men who receive at the end of the fifth or sixth year the Master's degree. A few of these colleges also grant yearly some doctorate degrees for work done in engineering courses. This program was gradually brought about by a few students with baccalaureate degrees who elected to pursue graduate work before moving into the wage earning realm of the profession rather than by any particular urge by the colleges for students to undertake graduate courses. The colleges have responded to this demand on the part of students not only by providing graduate courses, but also have aided very worthy students along their way by providing a considerable number of stipend paying scholarships some of which require research and teaching service in return whereas others are outright grants. Quite often the stipends are sufficient to cover the entire cost of attendance at college. To date this plan has been very satisfactory because there are enough men of outstanding ability applying for the fellowships to use all of them and to assure high quality graduate students both as to scholarship and personality.

The success of this very rigorously selected group of graduate students is now causing many other ambitious young men to think graduate degrees the "open sesame" to outstanding achievement in engineering. Herein lies certain advantages and dangers apparent to all educators. One of the outstanding advantages is the natural answer to the age-old question—What is the proper number of years for an engineering course? The graduate years have provided a way for adding much needed time decidedly better than the one time proposed way of making all engineering courses more than four years in length. Only a few years ago young men contemplating engineering as a career were saying—Shall we try to establish ourselves as engineers after graduation from high school, after two years of college work, or shall we complete a regular four year engineering course? This question has been most positively answered because we now know that under present-day conditions the probability of success in engineering without a college training is practically nil.

This statement is not intended to imply that in the future all engineers must have more preparation than that obtained in a four year engineering course. On the contrary, for many years to come the four year course will be all that is desirable for the larger number of engineers. It is most certain, however, that men who have been sufficiently interested in engineering to do graduate work have in general shown by their accomplishments that graduate work is desirable for those who are qualified to benefit by the additional training. The inference that all engineers cannot benefit by graduate work is made advisedly, because in the final analysis success as an engineer depends more upon one's ability to use the training he has secured than the amount of such training. Because this is true our colleges should be very careful in selecting the men permitted to take graduate work and in determining the content of graduate curricula, particularly when graduate work is to be carried on until the student earns a doctorate degree. In fact, the demand for the doctorate degree and the lack of an established policy among engineering colleges as to what type of curricula and what requirements seem proper for this degree have already caused industry to question the value of graduate degrees. Such being the case, is it not time for our society to establish some criterion as to curricula and standards of achievement in graduate work which will define in no uncertain way the types of work for which the holders of such degrees are qualified?

May I illustrate what I have in mind by suggesting consideration of an engineering education program somewhat as follows: The inclusion in the regular four year engineering course of those humanities or cultural courses which are being advocated as essen-

tial for the young engineer of today, and the granting of a Bachelor of Engineering degree for the completion of the four year course; a fifth year of work with about the same division of time, 75 per cent allotted to technical subjects and 25 per cent allotted to the humanities, in which may be included courses in accounting, business management or labor relations with the degree at the end of the fifth year of Bachelor of Electrical Engineering or Bachelor of Civil Engineering as the case may be; for a sixth year of work the degree of Master of Electrical Engineering granted to men who are excellent engineers and have research or executive ability. In this suggested program the doctorate degree should be reserved for men who in addition to being well qualified for regular engineering work are interested in physics and mathematics and have sufficient ability in these subjects to rate well as physicists or mathematicians. When such men graduate with the doctorate degree there will then be no question in the minds of employers in industry as to the significance of this degree in designating the type of work for which doctorate degree men are qualified.

THE HUMANISTIC BAND IN THE ENGINEERING CURRICULUM *

By WILLIAM E. WICKENDEN

President, Case School of Applied Science

In this morning's performance my friend President Doherty is cast in the role of pioneer—a man dwelling in tents, prospecting in new territory, while my part is the more prosaic one of a dweller in houses. The prospector may make a strike or, if his grub stake is sufficient, may discover a Klondike, while the city man must do his best to live within his means and to get ahead by the slower ways of prudent accumulation. If my ideas seem the more conventional, it is not because of feeble desire for the humanizing of engineering education, but because of a realization that most of us must approach that goal through the men and means at hand and by the sometimes fumbling processes of faculty democracy.

The curriculum in engineering may be likened to a structure of orderly nature with many closely articulated members. Some of these members are determinate in character, some relatively indeterminate. The loads to be borne by the first group are predictable and reasonable working stresses have been indicated by long experience. In consequence, our courses in mathematics, graphics, chemistry, physics, mechanics, thermodynamics, electromagnetism, and the like admit of fairly precise design. Those members are neatly and firmly dovetailed into our educational structure. The humanistic elements of the structure are less determinate in character. Their loads are often intangible and the response of the materials uncertain. Their design must therefore be tentative and the dovetailing is as yet crude in spots and imperfect in general.

What every experienced designer realizes is that any radical change in any of these members affects all others, and leads to inevitable modification of his general plan. If now we strain our metaphor to the point of investing each of these members with vested rights and voting power, and make the working design a matter of mutual compromise and consent, we come to a sober realization that the gains we desire and confidently believe to be possible within the inherent limits of the structure itself are likely to be slow and costly, rather than quick and easy to achieve.

* Presented at the 47th Annual Meeting, S. P. E. E., State College, Pa., June 19–23, 1939.

The humanistic members of this structure are broadly of two types—there are the studies in language and literature, with occasional outreaches into philosophy and the fine arts, and there are the social studies with occasional outreaches into psychology and ethics. There are also certain semi-humanistic members—the management studies which seek to bridge the gap between social theory and the working techniques of engineering. It is apparent, I think, that we have succeeded much better in dovetailing the language studies into our educational process than the social studies. For one thing, their uses are more immediate. Language has tool values which are quickly needed and are constantly emphasized by graduates, employers and mature engineers. The social studies, on the other hand, are likely to seem remote and intangible.

While the results still fall short of our ideals, the gains in reading, writing and speaking English by our students of today over those of twenty-five years ago, are almost startling if we may trust the comments of our graduates when they return to our campuses for events which call into play the students' powers of self-expression. I have just received at the hands of our departing seniors a gift of a sound-recording and reproducing set, principally for use in courses in public speaking. This gift is highly symptomatic of increasingly eager acceptance by our students and faculties alike of the tools and arts of expression. But when we pass into the area of literature, art and philosophy as instruments of culture, we find ourselves on the same remote and intangible terrain with history, economics and sociology. The eager acceptance and the close dovetailing granted to the tools of expression no longer exists.

The teachers, too, seem to move in different atmosphere: there is a whiff of envangelism in the air—a missionary zeal to save the young engineer from falling into the hands of the Philistines, rather than to make his natural existence more adequate and more wholesome. To be more prosaic and blunt, the temptation to be corrective rather than formative, is tending to defeat many otherwise laudable efforts for cultural advancement.

If language courses and language teachers are becoming closely dovetailed into engineering education, it might seem to indicate some closely-wrought philosophy function and method. As yet, there is little evidence of such a philosophy. What has happened seems rather to be simply the natural result of twenty years or more of fraternizing with engineers in the meetings and affairs of this Society. You can scarcely toss a pebble into any informal group at this convention without hitting a teacher of English, but the chances of hitting a teacher of economics or history or sociology or government are perhaps not more than one in a million. Since our teachers of English have adopted themselves into our professional

family, we have observed them edging away from the long beaten paths of the arts colleges and blazing first cautiously then boldly new trails germane to engineering. The attitude of our teachers of social studies, with few exceptions, seems conspicuously the opposite. Instead of coming to the mountain, Mahomet seems to be waiting in his tent for the mountain to come to him.

If there is no satisfactory solution of an effective humanistic education for engineers apart from the naturalizing of teachers of language, literature and social studies within our professional circle, then it is incumbent upon us to open up within this circle distinctive careers in which able men can expect to find fairly full satisfaction of legitimate professional ambitions. Assuredly, that must mean more than being a drill-master for none-too-eager underclassmen. No firstclass faculty can live by teaching alone. Firstclass men in any field of learning will always insist upon access to first-hand experience. For teachers of humanistic subjects in our engineering schools this is still largely an unsolved problem. We do not yet give them adequate opportunities to touch mature minds and to explore new areas of interest, nor is there adequate encouragement for research and writing, and still less for professional consultation and practice. Examine any pile of scholarly monographs on which some teacher of English has risen to prominence and you will find them utterly alien to the natural concerns of a school of engineering. If scholarly production of this character is to be the only road to recognition and preferment, we must expect an inevitable withdrawal or cooling of interest when any but a mediocre man is assigned to teach language courses to engineering students. Is it necessity or merely academic convention which drives a language teacher outside the domain of engineering in search of fertile soil for scholarly cultivation? Can we not aid him in clearing some virgin land where language, esthetics and philosophy can penetrate into the economic domain of construction and production? Our engineering faculties need not only productive scholars in humanistic branches, but also acutely need men who can do for us in some degree what William Lyon Phelps did for Yale—men whose personal enjoyment of books and experience of cultural activities have a vivid and robust quality which the student cannot resist. We shall not find these men ready grown. Much of the stimulation and guidance that will produce them, must come from the heads of our engineering schools.

I shall not attempt any diagnosis of the somewhat anemic state of the social studies in our group of colleges. We have not yet forgotten the chiding we received at the hands of President Roosevelt not quite three years ago. At the time we felt in it an undertone of pique, the irritation of a crusader for collectivism toward a

profession whose members adhered so consistently to the ideals of private enterprise, and who insisted upon applying the cold criteria of economic selection to public works conceived in a glow of social experimentation. The replies of our spokesmen were temperate and able, yet they left us with a certain lack of conviction of righteousness. Like the rich young ruler in the Bible, we had been following the letter of his admonitions for a decade, yet we were moved among ourselves to ask "What lack I yet?"

Some of us also recall the address of Prof. Whitehead of the Harvard School of business at the Cambridge meeting of two years ago on the subject "The Engineer as Servant of Society." Facing the fact that our courses in the social sciences are not conspicuously effective, he raised the question "Is the student taught anything he really needs to know?" and answered for himself that he did not think so, adding the opinion that we indulge in too much study of socio-economic theory in the abstract and of human relations in the mass and give too little thought in detail to the small human groups and intimate personal relations within which men as persons actually do their work. The result, as he observes it, is that while the engineer may have some smattering of history, economics and sociology in general, he is ignorant of the individuals and groups who actually use the machinery, products and plants which he creates.

Dr. Whitehead advocated as a subject for research by engineers and social scientists jointly the collaborative habits and activities of men and groups in the actual world of work. What seems significant is not so much the job proposed as that engineers and social scientists should tackle it together. Actually, the two types of men have little occasion to do actual work on the same team. Without disparaging the study of history, economics and sociology in their more general forms, Dr. Whitehead was emphasizing the fact that economics had its origin as a deductive science and remains still very imperfectly adjusted to the inductive ways in which engineers think and work. As long as economists and engineers merely talk at each other, it will continue to be so, but when the two get to doing actual team-work, a better understanding should develop.

To put our side of the problem bluntly, are we to look on the social scientist as a missionary dwelling among us to evangelize us with alien modes of thought, or shall we seek to make him over into a naturalized citizen of the world of technology? It is significant that all the major attempts to interpret the technological order of society, such as Mumford's "Technics and Civilization," have the air of being written by an outsider. Why have we no scholarly men within the circle of technology who are capable of interpreting it to our generation?

The sense of remoteness which now divides the engineers from the social scientists is not unlike that which divided engineers and physical scientists a generation or two ago, when the one worshipped at the shrine of horse sense and the other vowed his life to the immaculate conception of truth. No such gap exists today. Teamwork in education, in research and in industry have made it hard to tell the engineer, the physicist and the chemist apart. Even mathematicians and biologists are breaking into the circle. The natural result is that we educators of engineers are no longer grudging of time and wavering in emphasis toward basic science. Meanwhile we do lip service to the social humanities, but will probably continue to be grudging and hesitant in apportioning the curriculum as long as the area of active collaboration remains as limited and shadowy.

If we can get engineers and social scientists to doing actual work together the problem will tend to solve itself. We have perhaps more than half of the responsibility. Our part is to create a sphere of action for the social scientist within our domain which meet two conditions—on the one hand it must dovetail into our inherently concrete, inductive and instrumental ways of thinking and doing, and on the other it must offer satisfaction to legitimate aspirations for significant achievement and recognition. A career confined to elementary teaching will not suffice, nor will it suffice to encourage individual research in a merely passive way. To create teamwork, we shall probably have to put institutional backing, guidance and money into economic and social research in our engineering colleges, just as we have put it into physical and technical research. Our friends in the schools of agriculture and business have done so, and are achieving the results we still lack but are beginning to desire.

There will be more time and emphasis for social studies in the engineering curriculum when social scientists enjoy a more commanding influence in engineering faculties. Influence is not a matter of mere numbers, it is quite as much a matter of calibre. As soon as we succeed in naturalizing top-grade men in the social sciences into the engineering circle, by providing them with distinctive career possibilities in terms of advanced teaching, research, interpretation and consulting practice, our problems of time and place, of quality and acceptance for the social studies will begin to solve themselves. It is indeed propitious for all of us when a man of President Doherty's genius has the fortunate combination of freedom of action, of generous financial backing and resources in personnel under the guidance of Dr. Hotchkiss, to conduct a major experiment in naturalizing social science in an engineering curriculum.

When we set out to realize our dreams for the humanizing of engineering education, we run first into the limitations of men then into a second set of difficulties, the absence of a guiding philosophy for general design and of criteria of selection which will apply in the realistic realm of details. Our curriculum is a very practical processing sequence which uses certain human materials and certain means of learning and has a characteristic end-product in view. This product is a distinctive type of man, but yet one very difficult to describe. To say that he should be able to read English comprehendingly, write it with precision, and speak it clearly and confidently, that he should be able to use a foreign language as a tool when specified, that he ought to view man and society in the perspective of their evolution, that he needs to understand economic events and process in terms of universal laws rather than casual circumstances, and that he ought to gain some insight into the principles of human team-work and organization, is all good as far as it goes, but it does not provide the designer of the educational sequence and unit processes with working specifications. To say that a graduate in engineering ought to find delight in nature, in sport, in the various fine arts, and in the refinements of society, or to say that he needs a sustaining philosophy to meet the vicissitudes of life, is all true but platitudinous. Behind these generalities are the unanswered questions of detail which control the actual working processes of our curriculum and their selection.

To further illustrate this dilemma, suppose we were to summon our teachers of language and literature to a friendly inquisition and put to them a lot of questions like these: "How can we induce our upper-classmen to maintain or increase any skill in writing or speaking they may have gained in the freshman or sophomore years? Which of the two, music or poetry, is likely to prove the more congenial medium of culture and pleasure for engineers and scientists, and why? Is biography a more serviceable medium for the study of history than events arranged on a military, dynastic and political framework? Considering the characteristic mental bias of engineers and the fragmentary reading habits, engendered by a life of action, is it possible to interest them in formal philosophy? Is it better to ease them into the mansions of reflective and speculative thought through the lesser writings of great philosophers in essay form, or by such attempts at popularization as those of Will Durant?" Or suppose we put Whitehead's question to the social scientists; "Taking engineers as you find them, is it better to launch them on the study of society through its intimate working groups or through its larger structural units?"

The results of any such inquisitions we can all foretell—a

plethora of individual opinions, highly divergent and mainly subjective, and a scarcity of well-thought-out and experience-tested answers. We agree on generalities and grope in fog on details of working design. I have cited three reasons—all highly realistic—why in spite of our lip-service to the ideals of liberalization, we are making so little progress in creating a satisfactory curriculum: (1) We have not created career possibilities in our faculties which will attract and hold as teachers of humanistic branches men of commanding influence; (2) we have not been particularly successful in naturalizing teachers of humanities into the world of technology; and (3) we have only generalized ideals as guides to curricular design and lack answers to questions of detail.

There are other practical reasons in the way of rapid increase in humanistic content and emphasis. Our ship is overloaded with technological cargo, practically all of which has an earning value to some group or other among the crew. To ask the crew to jettison much of this revenue earning cargo in order to make room for a larger load of intangibles, is asking more than ordinary natures can stand. Instead we must build more cargo space. After much deliberation, we have decided to add this space above decks, as graduate work, rather than to lengthen the hull by adding one or two additional undergraduate compartments. This is taking time and most of us are not quite ready to reclassify cargo in the undergraduate and postgraduate sections. When we do, however, and it should be soon, more space should be reserved for humanistic materials.

In this connection, I am moved to make a plea for humanistic science. It would be unfortunate to leave the impression that languages and social studies are our only humanistic resources. Each of the sciences we pursue for definite functional values can be made to yield rich humanistic by-products, but my plea is for the sciences which stretch the mind and stimulate the imagination without pretense at creating salable skills, for what astronomy has to contribute to man's sense of cosmic order, or geology to his sense of orientation in time or biology to his sense of organic as distinct from mechanical forces and relations as the key to nature, and for what all science can reveal of the rôle of imaginative synthesis in the making of knowledge.

In view of all the considerations, both idealistic and practical, which have been set forth in these discussions of recent years, I am drawn to the conclusion that the faculties of our more liberal engineering colleges have not dealt ungenerously with the humanistic studies. In our present state of preparedness, I should not feel justified in asking of my own colleagues more than a two-year required sequence in language and literature, associated

with a two-year required sequence in history, sociology and economics and with the handling of each sequence varied in some degree to accord with the previous attainment of groups of students. To these prescribed courses I would add in the senior year fairly generous provision for elective work in humanities proper, in humanistic sciences and in the semi-humanities of business and management, insisting on a total of liberal studies at least equal to one year's work in a college of liberal arts in addition to all required work in the mathematical and physical sciences. Experience has indicated that this can be done with reasonably well prepared undergraduate students in full accord with the principles of "moderate diversity of curriculum, tending away from specialization" and "dominance of scientific and broadly technical content and emphasis," as set forth in the Report of the Board of Investigation and Coördination ten years ago, but still as valid as then.

May I add the personal opinion that the development of intellectual and personal maturity in our students is for many of our colleges a more urgent problem than the immediate liberalization of the curriculum. What I have long surmised is hardening into a conviction that the constant pressure of detail is obscuring for our students and teachers alike the things in education which are more important and more valuable than any quickly marketable knowledge. At the bottom, the problem is one of creating a conviction that an understanding of the relations of things is worth infinitely more than any knowledge of things in themselves, that the laws of thermodynamics embody a philosophy as fundamental as the universe, while the specific heat of steam is an item of information always to be found in a handbook, that the laws of electromagnetism are one of the noblest conceptual formulations of all science while the permeability of silicon steel is scarcely worth remembering, and that the ways in which men's minds and natures work are far more worth the knowing than any tricks of sales approach or business correspondence. If concern for revamping curricular details by deleting a little science here and a little technology there, and substituting a little conventional history or economics or civics should turn us aside from the path which leads back to fundamentals, the result is likely to be disappointing and may even be calamitous.

I do not share the fear that the ark of society is tottering and that the hand of the engineer must hurriedly be stretched forth to steady it. There is need for experiment in widening the scope of social studies, but there is also time for evolution. It is easy, I fear, to become unduly excited about the social responsibilities of engineering. These responsibilities operate in three phases.

There is the phase of research, the unhurried search for truth which may or may not have immediate application; the phase of invention and practical development for a given use; and the phase of economic application. I shall make bold to assert that responsibility for social consequences does not enter into the first phase at all, and that it enters into the second phase only to the extent of requiring that the product of invention and development be adopted as perfectly as possible to the service and convenience of man. No other social faith is possible to the man of science than that the advancing of knowledge and the provision of improved instruments of human work and living are part of the manifest destiny of mankind. Any other doctrine is a counsel of darkness and confusion. But social responsibility penetrates deeply into the third phase of engineering activity, that of economic application, and demands social vision and ethical enlightenment of the highest order. This problem lies very close to the core of an adequate education for engineering management. I have little expectation that we shall solve it in the under-graduate period of study. An adequate training in fundamentals of management remains, I believe, the most important piece of unfinished business in our hopefully emerging program of graduate study.

The temptation is always present to unload the problem of the engineer's humanistic education on the college of liberal arts by compelling him to take not less than two years of preliminary studies, as proposed in a recent bill introduced into the legislature of the State of New York. I believe this to be an effort to do a good thing in a wrong way, to seek cultural advance in engineering education by destroying its present unity, and am confident that if the plan were to be adopted, the results would be sadly disappointing. Coming at the end of a decade in which engineering education, because of its unity of humanistic, scientific and technical disciplines, has moved forward to a position of recognized leadership, this challenge from a radical group within the profession is doubly significant. Complacency is a far more deadly enemy to education than fanaticism. The only answer is to do a better job within the schools of engineering, than any one is doing outside of them.

FOREST CONSERVATION—A TASK IN ENGINEERING *

By WILSON COMPTON

Secretary and Manager, National Lumber Manufacturers Association, Washington, D. C.

Fifteen years ago the President of the United States established a National Committee on Wood Utilization, a coöperative public and industry enterprise. Its objective was simple: *Intelligent Forest Conservation.* It coined an expressive slogan: "To Conserve our Forests—Use Wood and Use it Wisely." This activity in another form but for a similar purpose is continued today in the Forest Industry Conference, also an undertaking in public and industry coöperation, and also under the auspices of the Departments of Agriculture, Commerce and the Interior.

To Conserve our Forests—Use Wood Wisely

For the consideration of engineers and of teachers of engineers I shall seek no more authoritative starting point for discussion of American forest conservation than the simple appeal of this National Committee, namely, "Use Wood and Use it Wisely."

This has three important implications:

1st. If we wish to *save* our forests we should freely *use* their products;

2nd. We should avoid preventable forest wastes; and

3rd. If we use our forests wisely and their products freely and without needless waste, nature will restore the forests.

There is no other country in the world to which so simple a conservation formula is so well adapted. Relatively we in this country have always had, we still have, and we will continue to have the most extensive forest resources available to any people. They are the most diversified. Including both softwoods and hardwoods, they furnish practically every useful type of wood known to the commerce of the world. Even more important, our forests with minor exceptions are accessible to transportation and to convenient industrial and commercial use.

Forest protection; wise use of forest products; and natural reforestation! This is the simple basic conservation formula with

* Address delivered at 47th Annual Meeting, S. P. E. E., State College, Pa., June 19–23, 1939.

which I start. It provides only a *minor* place for so-called "intensive forestry" such as is in vogue, for example, in the modern forests of Germany and of other densely populated countries of the Continent where forest resources are scanty and wages are low. It provides a *major* place for "sustained yield forest land management" which seeks gradually to adapt forest cutting to forest growth and to the objective of permanent operation, continuous employment, and dependable sources of livelihood for forest-dependent communities.

Natural Reforestation

In proportion to our population we have ten times as much commercial forest land area as, for example, has Germany, whose elaborate system of manicuring its forest lands has for decades been so highly touted in this country. We don't need intensive forestry like that. It costs too much and it is not necessary. What we do need is a condition in which forest industry, its output of useful products and its opportunities for useful employment may be permanent and dependable, and in which the forest lands when cut-over are left in a condition *favorable to natural reforestation.* Beyond that forests need protection from fire, insects and disease; and the forest industries need adequate markets for their products. Neither of these conditions has so far been sufficiently met.

Now I am not going to make a conventional speech on forest conservation. No outcry; no "pointing with pride" or "viewing with alarm"; and no politics! But I hope some plain economics, logic and science applied to some plain facts. Some things I shall say you may regard as fantastic; others you may think are not so. But after all, I shall not try to do your thinking for you; and as to my premises and conclusions, if you think they are unsound, I merely suggest that you put the facts upon your own adding machine and find your own conclusions.

I have no timber to sell and no pet theories to advance. I take it that you are interested to know:

> How our forest resources may contribute to national betterment;
>
> How engineering may aid that process; and
>
> How to that end engineering education can start men and women toward necessary knowledge and—may I say—the inspiration and determination which often marks the difference between hopes and achievements.

The engineer's part in forest conservation and in the utilization of forest products will, in my judgment, be much greater than most of you in your own engineering schooling and in your own engineering

practice have been accustomed to think. I am speaking not only of civil, mechanical and architectural engineering, but also of chemical, marine and aeronautical, and of the inventiveness of the scientific mind.

What is needed is more conservation and less conversation about conservation. But we should know where we are going and not merely that we are on the way. Engineers work and think with figures. So one bold enough to address engineers on a subject of this kind should be prepared to support his views with facts and not merely with a cloud of ambiguous words.

Conclusions

So may I start with the conclusions which I shall undertake to sustain.

1st. The American forest problem is fundamentally one not of scarcities but of surpluses; not of "timber famine" but of timber abundance.

2nd. The timber famine publicity of the last half century was effective in stirring public interest on forest conservation, but it put the forest problem in a false national perspective.

3rd. Engineers of recent school generations, with few exceptions, have been taught little timber engineering.

4th. Forest products in their diversified mechanical and physical forms and chemical derivatives are not likely to be generally supplanted by other materials.

5th. Engineering schools in the interest of their students, in their own interest, and in the public interest, should more thoroughly explore the likely place of forest products in our future national economy and should make more adequate provision accordingly for appropriate engineering education.

Opportunities in Forest Fields

In terms of potential I doubt that any of our major natural resources offer to the scientist or the engineer more important and more extensive opportunities. Forests like farms, and forest products like farm crops, are so familiar as to be taken for granted. The lumber industry is the oldest American industry; geographically the most widespread; nationally the most familiar. Some of you see in it only the material for framing and covering of houses and barns; for the structure of bridges and towers, wharves and docks; or just as something which may burn or rot or be eaten by termites. Yet there are 48 industries in the United States using 10 million feet of lumber annually. There are over 4,500 identifia-

ble construction and industrial uses for timber products as compared with 950 for steel, its nearest competitor; and about 600 for paper and pulp which in turn are largely forest products.

The diversified uses of wood products the world over are being aided by preservative and protective treatments, by fire-proofing, glues, laminations and plywood; timber joint connectors; and the reassembly of natural wood fibers in controlled form by pulping; by the explorations into wood micro-cellular structure and by the modern derivative chemistry of wood cellulose and lignin. These are creating new industries and new jobs.

If wood is the most widely useful material of industry it is due largely to this range of diversified mechanical, physical and chemical uses. Mechanically, weight for weight it is one of the strongest materials known. Chemically, it is the most prolific provider of cellulose. An acre of pine trees in Georgia, for example, will produce four times as much cellulose as the same acre in cotton, and in a much more economically harvested form. That fact alone I predict will eventually mean a million more jobs in the South.

So I enumerate five general characteristics of our American forests and American woods which, as it seems to me, are significant from the engineering standpoint:

1st. Versatility of qualities and physical characteristics.
2nd. Wide distribution and abundance of supply, both present and future.
3rd. Convenient accessibility.
4th. Indefinite renewability at low cost, a characteristic shared by no other major natural resource.
5th. Prodigious growth and economical assembly of raw material.

Many of you know of the United States Forest Products Laboratory. It may be concealed among the badgers of Wisconsin. But it is the research mecca and the scientific oracle of American forest products; and it is doing a great work. What I have said *in brief* is to a large extent what the Forest Products Laboratory has said *in extenso*.

Importance of Forest Conservation

What are our forest interests and our forest needs? What are our forest objectives? What do we want with forests? and What do we do with them?

1st. To protect the watersheds of navigable streams, to aid uniformity of stream flow and flood control.
2nd. To prevent or reduce soil erosion—for the protection of soil fertility.

3rd. To protect wild life and to provide game cover, an objective of interest to every nature-loving American.
4th. Outdoor recreation—for public health and general welfare.
5th. Preservation of scenic beauties—for the maintenance of spiritual as well as economic values.
6th. National defence.
7th. To keep idle lands productive—a national economic objective.
8th. To provide partial alternative employment for American farmers—a form of "farm recovery."
9th. To extend the opportunities for profitable employment of labor and capital, and for dependable livelihood of communities dependent largely on wood-using industries.
10th. To produce timber and wood to supply a raw material for construction and for the fabricating and wood-conversion industries.

Conservation History

Forest conservation is a modern invention. Present and prospective timber supply and present and prospective timber needs have been a prolific source of controversy for nearly half a century. Originally the forests, like the Indians, were the enemy of settlement. Woods were regarded as a nuisance; and they were. So the urge of land hunger drove out the forests. That tradition lasted in this country till well toward the end of the last century. I recall my grandfather, pioneer midwestern farmer, tell of the Southern Ohio logging "bees," a sort of community festival in which the accommodating neighbors would join in rolling together logs to be burned to clear the land. Land hunger again! My grandfather, in the rich Miami Valley, cleared a large farm of some of the finest walnut timber that ever grew. The hewn timbers of his old barn and the siding of the grain bins, still standing, would make table tops for kings. Before his death he remarked that if he had not turned a plow into his land, but had left the walnut trees, he would have made more from the timber than he had made from the farm.

Hindsight perhaps! But I am not so sure. If my grandfather and millions of others had not cleared the farms, settled the land, and started the local industries and trades, these walnut trees would have had little value and less use.

Place of Forest Conservation

Crusaders and reformers about fifty years ago invented the "forest conservation movement." But it was not until the time of Theodore Roosevelt that conservation became a part of the national vocabulary.

Forest conservation sentiment in this country was built on fears —fears of a national "timber famine." The United States Forest Service was founded, and its appeal for public financial support largely predicated, on "timber famine" publicity. The National Forest System was originally established as a national safeguard. There is still occasional reticence and reluctance about discarding this traditional appeal to public emotion and public fear.

"Timber Famine" Propaganda

The purpose of these predictions almost always was sincere, constructive and courageous. In some important respects, however, their effect has been destructive. Even within the last decade there have been official and semi-official proclamations of the "imminent pinch of timber scarcity." These and similar statements, intended to stimulate forest conservation, have often been exploited, amplified and exaggerated to defeat the very purposes they were intended to foster.

Dramatic prophecies of timber famine and national misjudgment of timber supply prospects thirty or forty years ago encouraged private timber investment and timber speculation, particularly in the West, on too large a scale. Again during more recent years, repeated public warnings of timber shortage and of the imminent prospect of high prices have been one of the great factors in encouraging the substitution of other materials for timber products.

Much of this substitution has been due of course to the clear superiority of other materials. To that extent it is sound and desirable and should be permanent. But there is reason to say that much of it, also, has been due to unfounded anxiety over the permanent availability of suitable lumber and timber products, unjustified fears of prohibitive prices, and a vague but potent undercurrent of public impression fanned by zealous competitors that rather is it a patriotic duty to aid forest conservation by refraining from the use of forest products. Abandonment of their use for these reasons is unsound and has tended to discourage and retard conservation and reforestation.

Congressional Inquiry

What are our forest resources? What is the present condition and the prospect of permanent timber supply? And in what way can these resources be made to contribute to useful industry, dependable employment and social welfare? At the request of the President of the United States, Congress has recently created a Joint Congressional Committee on Forest Inquiry. It is bidden to study this problem and to recommend appropriate national

policy and appropriate legislation. The Forest Service as an aid to this Inquiry has recently compiled the most comprehensive surveys ever made of our national forest resources; the condition of our forest lands in both public and private ownership; the drain upon these resources through cutting and through destruction by fire, insects and disease; and the present and prospective timber growth.

These surveys show some astonishing conditions which I should like briefly to analyze. I do not wish to assail you with a barrage of statistics. But engineers I think prefer exact information. In what I have to say I am merely using the findings of the United States Forest Service itself and plain conclusions to which they point. I am not now judging the accuracy or completeness of the Forest Service surveys. I am merely, for this purpose, accepting them as a reasonable base for conclusions which I think should be as significant for the engineers as they are for the forest products industries. For your permanent record I am adding the exact statistical comparisons on which these conclusions are based.

Extent of Forest Resources

In Continental United States are 630 million acres of forest land. That is almost exactly one-third of our total land area. Of this about three-fourths is Commercial Forest Land. Over one-fourth of *this* is in public ownership; nearly one-third is in farm wood lands; and less than one-half in the ownership of individuals and lumber and timber companies.

Not quite one-half of the Commercial Forest Land area is in saw timber. One-fifth is in merchantable cordwood. One-sixth more is in fair condition of reforestation; and one-sixth is substantially barren of commercial regrowth. The national commercial timber supply in 1938 was 520 billion cubic feet. The annual removal by cutting is 11 billion; through destruction by fire, insect and disease, 2 billion; and the estimated annual drain, therefore, 13 billion feet or about one-fortieth.

Offsetting this drain is a present annual growth of 11 billion cubic feet; and a prospective growth on lands now bearing old-growth or virgin timber, of an additional 3⅓ billion cubic feet. This means a total present and prospective annual growth on the Commercial Forest Lands a billion cubic feet greater than the present estimated annual drain from all sources.

Forest Growth and Forest Drain

This means that if all our old growth or mature Commercial Forest Land areas are cut-over—as eventually they should be—and

if these lands grow new timber at a rate no greater even than the *average* rate of growth on the forest lands already cut-over, the annual commercial timber growth will exceed the annual commercial timber drain—including timber now destroyed by fire, insect and disease—by more than a billion cubic feet, or by 8 per cent.

This is true of the forest area of the Nation as a whole. It is also true individually of 4 of the 6 principal timber regions: the Northeastern States, the Lake States, the Southern States, and the Pacific Northwest. It is true in the Lake States, however, only because forest depletion during the past years has so vastly reduced the *rate* of timber cutting in that region. It also is *not* true of the Central States where the drain will exceed the growth by nearly 60 per cent; nor in California where the drain will still exceed the growth by 18 per cent; and in the Douglas fir region of Western Washington and Oregon where the excess would be 14 per cent.

But in California, if the further cutting of virgin timber leaves the forest land in a condition for reforestation only as favorable even as the so-called "cordwood areas," the annual growth will exceed the drain by 7 per cent, and on the same basis by 4 per cent in the Douglas fir region which for many years has been, and for many years will continue, the source of the heaviest timber cutting.

The estimates of Annual Timber Drain are themselves rather generous. For example, they assume an annual production of lumber of nearly 28 billion feet as compared with 20 billion feet last year and this year apparently about 23 billion feet. In fact, at no time in nearly ten years has the annual production of lumber been as great as 28 billion feet. These estimates of Timber Drain include more than 2 billion feet of annual destruction of timber, principally by fire. It is, of course, hoped and believed that the losses from this source will be gradually and substantially reduced. The estimates of Timber Growth also do not include trees less than 6 inches in diameter.

These comparisons are technical and hard to follow. But they contain the most significant information on Timber Supply, Timber Use and Timber Growth published in the last quarter century in this country. Their meaning after all is rather simple:

> There is and there will be no national shortage of timber supply in either softwoods or hardwoods. There are, and will be, some important local and regional timber shortages which gradually ought to be rectified. To balance timber drain with timber growth, we need only to keep the fires out of the woods, and reasonable protection of forests from destruction by insects and disease. That will provide permanently a quantity of Saw Timber, Cordwood and Pulpwood substantially greater than the present timber drain.

Growth Condition of Forest Lands

With respect to privately owned commercial forest lands the Forest Service finds that 20 per cent are under some form of scientific forest management, including 14 per cent of industrial forest areas; 30 per cent of farm wood lands. More significant is the finding that of all forest lands in private ownership—scientifically managed or not—farm wood lands and lands in industrial ownership, 83 per cent are in what the Forest Service describes as "productive condition"; including 89 per cent of the lands in Federal management; 66 per cent of the State, County and Municipal forest lands; 84 per cent of the farm wood lands; and 82 per cent of the lands owned by individuals and lumber and timber companies.

The 17 per cent ratio of forest lands not in "productive condition" should, of course, be reduced. But the situation determined by these surveys of the Forest Service is so much more encouraging than the fears of only a few years ago, that they may be fairly stated to have buried the national "timber famine" bogey seven leagues under the sea.

This does not mean that we have a satisfactory regional distribution of timber growth. We do not have. Or that our forest lands are producing timber to their capacity. They are not. It does mean that the problem is not to combat or protect against a "timber famine," but to secure new markets and develop new uses for forest products, and especially of finding how better we can use our national resources in forest lands, mills and men. Wise legislation may help. Unwise legislation may hinder. But to the extent that this problem is solved in our time it will be solved largely by science and engineering.

Improvements in Uses of Timber Products

I have been largely generalizing, seeking to cover a broad subject in a short space. Now for a concluding moment let me particularize. I have said that I think engineering colleges would be warranted in giving students more opportunity for instruction in timber and forest products engineering. Let me be specific with a case history.

Following the war many European countries were forced by economic limitations to seek more economical or more efficient methods of building. One of the major construction developments on the Continent was the so-called Joint Connector System of Timber Construction, based on the use of dowels, rings and plates, mostly metal, in the timber joints.

These timber Connectors—or at least the good ones—were patented. With the help abroad of the Department of Commerce, over a period of years, we secured the American rights of these various patents. The Forest Products Laboratory had made thousands of tests which showed that the use of these Connectors increased by from two to five times the strength of ordinary bolted timber joints. In coöperation with the National Committee on Wood Utilization these results were published in 1933. Then we set up what is now known as the Timber Engineering Company. We turned these patents over to it to be so administered as to make these Connectors available at the same price to anyone, anywhere in the United States who wanted to use them in construction.

These so-called "TECO Timber Connectors" were first made available in this country in 1933. At that time Timber Connector construction was unknown here. If construction was of timber it was either bolted or nailed. More likely it was of steel or concrete. Yet within six years more than 14,000 timber structures, that we know of, have been built using the TECO Connectors. These include bridges, wharves, piers, towers, derricks, garages, airports, barracks, barns, arenas, auditoria, exposition buildings, factories and warehouses. This TECO Connector construction alone in less than six years has used five hundred million feet of lumber. Most of it was in direct competition with other structural materials.

Timber Engineering

The U. S. Bureau of Standards, in a recent report entitled "Materials Improvements," states in part:

> Wood continues to improve its standing in the engineering field. Grading, standard working stresses for structural timber, better practices in the preservative treatment of wood, more efficient timber joints, the introduction of laminated construction and an increasing use of structural plywood are some of the factors which have brought this about. . . . The use of metal dowel connectors for timber framing continues to grow.

We have ourselves during this period been making other tests. We have developed many improvements in the Connectors themselves and in the system of Connector construction applied to our American woods. In all this time our greatest single difficulty has been to find engineers who really knew how to design structures economically in timber—in fact, to design structures in timber at all. Engineers everywhere seemed to know how to design in steel and concrete. In their schooling, timber design evidently—and with a few exceptions—had been a forgotten subject or a neglected art.

We sought engineers who could teach *us*. But for the most part our little Timber Engineering Company has had to teach *them*. As I left our office yesterday the General Manager of the Timber Engineering Company told me that after several weeks of inquiry, he is still looking for a young engineering school graduate with two qualifications: First, that he have some competent background of education in timber design; second, that he want a good job. He says there are many who would take the job but so far none who know how. So perhaps again we will do what some engineering school could have done but didn't do.

I cannot but believe that the "timber famine" propaganda of past years has been partly accountable for this deficiency in engineering interest in timber products. It seems now, however, so far as forest conservation is concerned, that industry, Governments, the public and the schools have at long last quit "fighting windmills." If that is true we have at least made that much progress.

In a report of the National Academy of Sciences, accredited by some of the greatest names in American science, published a few years ago, appears this candid statement on "The Role of Research in the Development of Forestry in North America":

> The possibility of stimulating private owners to operate their timberlands upon a sustained yield basis is a difficult and time-consuming task. It . . . involves the revision of existing systems of taxation, the stabilization of forest land ownership and the readjustment of a complex of unfavorable economic and industrial factors . . . and the necessity of overcoming the natural handicaps of deferred financial returns. . . . Unfortunately the general economic and financial status of the lumber industry, particularly in the Pacific Northwest, tends to encourage an extremely wasteful and destructive, rather than a conservative, type of forest utilization. . . . Forestry in the United States is still in its pioneer stages. It must solve a complex of extremely difficult and involved sociological, political, economic and industrial problems.

Forestry in America has still a long way to go. European forestry and forest industry have developed gradually and fitfully through a long, tedious and costly process of trial and error and of gradual adaptation to changing national and local economic and political conditions. In this country we are following a somewhat similar route. But we are on the way!

Some weeks ago in the Foreword of a book entitled "Lumber Industry Facts—1939" I stated the public and industry problem of Forest Conservation as I view it. It may be equally pertinent to your interest here as engineers and as teachers of engineers:

> Forests are America's greatest renewable natural resources. Wood: in its mechanical uses, fiber forms, and chemical derivatives, is the most

versatile material of industry. Lumber continues the most generally useful and most economical material for home-building. Usable cellulose fiber can be produced in larger volume and harvested in trees more economically than in any other commercial form. Nearly one-third of the area of the United States is useful, by nature and in the national economy, chiefly or solely for growing timber. The modern world-wide trend is toward an increasing and more diversified use of lumber and timber products. In these facts lies our great opportunity for permanent forests and permanent forest industry!

The lumber industry is the oldest great American industry. More than any other, it has blazed the trails westward. For economic reasons it has been a migratory industry. For economic reasons it is now "settling down." Formerly its livelihood came from the rush of "liquidation" of virgin timber. Hereafter its livelihood will come from the conservative management of its forest lands, from widened markets for its products and from forest industry conceived of as a permanent enterprise and a continuing source of employment.

The lumber industry is in a difficult transition. The great migration is over. The future of the industry is in making the most of its assets in forest lands, mills and facilities for the distribution of its products. This means more research; more science; lower costs; better products; more efficient distribution. Especially it means better understanding—more Facts.

With the aid of science, sound public policy, and well-informed understanding—within and without—the forest products industries can eventually provide new and dependable sources of industry and employment. To that extent and in that way it may add its part to the solution of our greatest national economic problem—of providing an opportunity for every man who has the will to work.

APPENDIX—TABLES 1 TO 7

TABLE 1

UNITED STATES FOREST LAND AREA

(In Million Acres—1938)

Region	Total	Non-Commercial	Total	Commercial Forest Land							
				Saw Timber			Cordwood	Fair and Satisfactory Restocking	Poor to Non-restocking	Private Ownership Under Management	
				Total	Old Growth	Second Growth				Area	Per Cent
Northeastern	62.1	2.8	59.4	21.2	8	13.2	15.4	14.7	8.2	12.6	23.2
Central	29.3	.1	29.2	9.7	.4	9.3	8.7	5.2	5.7	4.2	15.4
Lake	55.6	3.2	52.4	7.1	3.6	3.5	10.8	13.4	21	4.2	13.3
South	210.6	8.1	202.5	96.7	25.1	71.6	48	29.1	28.8	42.4	22.6
West Coast and Inland Empire	99.5	25.7	73.8	44.1	37.2	6.9	12	8.5	9.2	3.5	12.5
California	48.2	34.5	13.7	11.4	8.7	2.8	.1	.2	1.9	2.7	39.2
South Rocky Mountains	102.6	71.9	30.7	22.7	17.9	4.8	5.9	.2	2	.4	8.2
Total—U. S.	630.2	168.5	461.7	212.9	100.8	111.1	100.8	71.3	76.7	70	20.5

Source—U. S. Forest Service.

TABLE 2

UNITED STATES—TIMBER RESOURCES (1938) AND REMOVAL (1936)

(In Billion Cubic Feet)

Region	Saw Timber	Cordwood Timber	Total Timber	Annual Removal	No. Years Supply—Not Including Growth
Northeastern	16.7	31.2	47.9	1.37	35
Central	3.2	8.8	12	.91	14
Lake	15.7	10.1	25.8	.98	26
South	88.1	49.9	138	6.69	21
West Coast	154.3	42.8	197	2.85	70
California	60.5	2	62.6	.5	125
Total	364.4	154.7	519.1	13.46	40

Source—U. S. Forest Service.

TABLE 3

UNITED STATES—SAW TIMBER RESOURCES

(In Billion Feet Board Measure—1938)

	Softwood	Hardwood	Total
Board Feet	1,493.1	270.5	1,763.6
Cubic Feet	296.9	67.5	364.4

Source—U. S. Forest Service.

TABLE 4

UNITED STATES—TIMBER GROWTH AND REMOVAL

(In Million Cubic Feet)

	Softwood	Hardwood	Total
Growth (1938)	5.93	5.35	11.28
Removal (1936)	8.06	5.4	13.46

Source—U. S. Forest Service.

TABLE 5

UNITED STATES—TIMBER QUANTITY AND REMOVAL

(In Billion Cubic Feet)

	Saw Timber		Cordwood Timber		All Timber	
		Per Cent		Per Cent		Per Cent
Quantity (1938)	364.4	100	154.6	100	519	100
Removal:						
Cut (1936)	8.8	2.4	2.6	1.7	11.4	2.2
*Destroyed (1936)	1.1	.3	1.0	.7	2.1	.4
Total (1936)	9.9	2.7	3.6	2.3	13.5	2.5
Lumber *only* (1936)	5.8	1.6				
Lumber, Shingles, Veneer and Cooperage *only* (1936)	6.3	1.7				

Source—U. S. Forest Service.

* By fire, insects, disease.

TABLE 6

UNITED STATES TIMBER DRAIN AND GROWTH TOTAL COMMERCIAL FOREST AREA

(In Million Cubic Feet)

Region	Drain	Growth			Ratio Drain to Growth	
		On Forest Lands now Cut-Over	On Forest Lands to be Cut-Over	Total	Based on Lands now Cut-Over	Based on Total Commercial Forest Lands
Northeastern	1,370	1,260	197*	1,457*	1.1	.94*
Central	907	568	7	575	1.6	1.58
Lake	983	979	71	1,050	1.0	.94
South:						
Coastal Plain	1,691	1,626	288	1,914	1.0	.88
Piedmont	1,812	2,143	238	2,381	.8	.76
Mountain	1,487	893	63	956	1.7	1.56
Delta	573	478	177	655	1.2	.87
Pine-Hdwds.-West	1,126	1,355	190	1,545	.8	.73
Total	6,689	6,495	956	7,451	1.0	.90
Columbia River Basin:						
West Coast	1,833	917	685	1,602	2.0	1.14
Interior	1,016	717	860	1,577	1.4	.64
Total	2,849	1,634	1,545	3,179	1.7	.89
California	501	155	268	423	3.2	1.18
South Rocky Mts.	164	196	274	470	.8	.35
Total—All Regions	13,463	11,287	3,318	14,605	1.2	.92

Source—U. S. Forest Service.

* Information in these columns computed from Forest Service published data.

Based on conservative assumption that the present "Old Growth" timber lands when cut over will provide *additional annual timber growth* per acre in each indicated region *at least equal to the average growth per acre on the forest lands heretofore cut over*, as shown by the Forest Service reports.

TABLE 7

Ownership and Condition of Commercial Forest Lands

(In Million Acres and Per Cent—1938)

Region	Total	Federal	State County Municipal	Private		
				Total	Farm	Industrial
A. In Productive Condition						
1. Commercial Forest Land Area						
Northeastern	51.3	1.4	3.1	46.7	15.6	31.1
Central	23.6	1.3	.2	22	15.4	6.6
Lake	31.4	4.4	7.3	19.4	9.3	10.3
South	173.8	11.2	1.3	161.3	74.7	86.6
West Coast and Inland Empire	64.6	37.9	3.4	23.2	2	21.3
California	11.7	6.1	.5	5.5	.2	5.3
South Rocky Mts.	28.7	24	.5	4.3	.1	4.2
Total—U. S.	385	86	16	283	117	165
2. Percentages of Total Commercial Forest Land Area						
Northeastern	86%	96%	88%	86%	92%	84%
Central	80	91	96	80	76	92
Lake	60	64	52	62	62	63
South	86	87	74	86	87	83
West Coast and Inland Empire	87	90	85	84	88	84
California	86	90	100	81	70	82
South Rocky Mts.	94	95	94	85	80	85
Total—U. S.	83	89	66	83	84	82

Ownership and Condition of Commercial Forest Lands

(In Million Acres—Total United States—1938)

All Lands	461.7	96.7	24.1	340.9	138.8	202.1
Saw Timber	212.9	59.6	4	149.2	56.8	92.5
Cordwood	100.8	14.6	5.5	80.7	37.9	42.8
Fair to Satisfactory Restocking	71.3	12.1	6.4	52.8	22.7	30.1
Poor to Non-restocking	76.7	10.4	8.2	58.2	21.5	36.7
Per Cent of Total	17%	11%	34%	17%	16%	18%

Source—U. S. Forest Service.

CONSERVATION OF MINERAL RESOURCES*

By RICHARD J. LUND

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Washington, D. C.

It is a privilege and pleasure, I assure you, to take part in this general conference on "Conservation of Natural Resources"—a subject concerning which educational groups have for many years carried on important research and study, and to which governmental attention, both state and federal, has recently been directed. I shall endeavor to indicate some of the problems involved in the conservation of minerals; to analyze briefly the ways in which mineral extraction has and has not followed conservational lines, and the factors responsible for wasteful practices; and to portray the industry's efforts to promote better stability, together with activities of government, both those designed to further conservation and those which, although their primary object lies in different fields, may have distinctly anticonservational effects.

Endowed with a rich heritage of mineral wealth, the United States has for decades led the world in production and consumption of fuels, metals and nonmetallic minerals. Products of the wells, mines and quarries have become so intimately interwoven into the fabric of present day industrial development that progress in the immediate future, at least, will almost inevitably be conditioned on a continuation of abundant supplies of these vital materials. Fortunately we may take pride and comfort in the fact that we are still the No. 1 "have" nation.

Yet we are faced by the equally important fact that mineral resources are irreplaceable—that once used, they are gone forever, except for a number of the metals which are constantly reclaimed and reused. Thus, having drawn so heavily in the past upon our mineral storehouse, and confronted with definitely limited supplies for the future, the realization that the remaining amounts should be exploited with a minimum of waste and used with prudence has led to accelerated thought and action in respect to their conservation.

Conservation Defined

The various concepts as to what should be included in a proper definition of the term conservation are almost as many as the

* Presented to the 47th Annual Meeting, S. P. E. E., Pennsylvania State College, June 19–23, 1939.

thousands of scientists, economists and politicians who have written or spoken on the subject. One of the most comprehensive definitions of the term known to the writer was made a few years ago by twenty-seven units of the University of Wisconsin. This was quoted by Professor C. K. Leith in an address before the American Association for the Advancement of Science in 1935, which I repeat as follows:

> Conservation is the effort to insure to society the maximum present and future benefit from the use of natural resources. It involves the inventory and evaluation of natural resources; calls for the maintenance of the renewable resources at a level commensurate with the needs of society, and requires the substitution, where the conservation of human energy permits, of renewable or inexhaustible resources for those which are non-renewable, and of the more abundant non-renewable resources for the less abundant ones. It not only seeks to eliminate waste of resources if use is economically feasible, but also looks forward to improvements in techniques of production and use, and requires that there be prompt and proper adjustments to advances in technology. It thus appears that conservation involves the balancing of natural resources against human resources and the rights of the present generation against the rights of future generations. It necessitates, moreover, the harmonizing of the procedures and objectives of conservation with the conditions of the present or future economic order, and calls for a careful allocation of duties and powers among private and public agencies.

Undoubtedly there are many people closely concerned with the mineral industry who feel that this platform goes either too far or not far enough—that some "planks" should be omitted and others added. However, for purposes of evaluation, let us use this as a starting point, and outline briefly in what respects the conditions of these terms have or have not been observed.

Inventories Made Repeatedly

During the past several decades experts in various branches of the mineral industry have repeatedly endeavored to present a true picture of our mineral reserves. Experiences have proved these of decidedly varying reliability. Petroleum reserves, for instance, were grossly underestimated in early reports, and views concerning future supplies of this vital resource are now assuming a more optimistic tone than was the case fifteen years ago.

The latest attempt to inventory our principal mineral reserves was made in 1936 by Kenneth Leith and D. M. Liddell.[1] Although

[1] Leith, Kenneth, and Liddell, Donald M. "The Mineral Reserves of the United States and Its Capacity for Production." Prepared for The Planning Committee for Mineral Policy, National Resources Committee, Washington, D. C., March, 1936.

developments during the short time since this study was made have revealed a number of inaccuracies, it still presents a broad picture with which there is quite general agreement. Summing up the situation they say:

> Coal is perhaps our most abundant mineral resource. Beds now known, which can be mined under present conditions, have reserves sufficient to last 4,000 years. Iron ore, limestone, gypsum, aluminum and molybdenum are also materials which last far beyond any period for which we should feel concern. On the other hand, there are several minerals whose reserve life can only be measured by the decades, and in the cases of these, very few decades will elapse before their exhaustion. Oil will last, at its present rate of consumption, for some 40 years, but changing economic needs and processes will alter the rate of use and consequently change the period of its depletion.
>
> The reserves of lead, gold and silver may last for a few decades only; lead and silver could, conceivably, be depleted in only 20 years. Copper and zinc will probably last longer than lead and silver, but the period before their exhaustion will also be comparatively short. . . . For another group of minerals, the supply is already deficient; for some, such as nickel and tin, virtually non-existent.

In recent years the petroleum industry has summarized the proven reserve situation annually, and surprising as it may seem, discoveries continue to outstrip production.[2] Similar developments in other branches of the mineral industry may greatly lengthen the life of reserves now estimated.

Substitution of More Abundant for Less Abundant Minerals

In general, it may be said that production and use of minerals is roughly in proportion to known available supplies. The notable exceptions comprise the displacement of coal by oil and natural gas. This may be justified in many instances on the ground of conserving human energy or through marked increase in convenience or efficiency. But the great invasion of coal markets by fuel oil and natural gas piped long distances for burning under stationary boilers must be marked down as definitely anticonservational.

Mere mention of the term substitution opens up a wide vista of possibilities, some of which may very materially affect present concepts of conservation applying to minerals. It has been remarked that there is scarcely a use to which any metal is put that cannot be met with some other metal or non-metal with varying degrees of efficiency. Practical chemical research has produced nothing less than wonders in the recent past, and it is indeed haz-

[2] Pogue, Joseph E., "Economics of the Petroleum Industry." The Chase National Bank of the City of New York, March, 1939.

ardous to delimit the extent to which such materials as plastics may invade markets previously considered safely insured for minerals.

This consideration has repeatedly been minimized by conservationists, and it is admitted that it is decidedly unwise and shortsighted to go ahead blindly "skimming the cream" of our resources with the hope or trust that generations in the future will develop suitable substitutes. But if these substitutes *are* developed and actually *do* displace minerals which are still abundant, contemporary conservational efforts made effective at increased expense to society would prove false economy.

Recent scientific developments, in my judgment, call for considerably more attention to this trend in future discussions of mineral conservation.

Improved Production Technique

Another important prerequisite to effective conservation of minerals is continued improvement in technique of exploration, production and beneficiation, thus facilitating discovery of new deposits, profitable extraction of lower grade or less accessible material, and increased recoveries. The past record of the mineral industry is brilliant, indeed, in this respect.

A few examples are cited for emphasis:

A. Exploration.

1. Refinement of geologic procedure involving improved stratigraphic analysis and correlation by means of micropaleontology and insoluble residue methods.
2. Great advances in geophysical exploration methods.

B. Production.

1. Application of open-pit and block caving mining methods, making possible daily tonnage outputs measured in thousands or tens of thousands of tons of extremely low grade materials.
2. Mechanization of underground operations, with tremendous improvements in technique of cutting, drilling, shooting, loading, transportation, hoisting and ventilation.
3. Refined methods of surface drilling, permitting sinking of oil wells to depths up to two and three miles. Commercial wells over a mile deep are now commonplace, those up to two miles in depth not uncommon, and recently a well in California passed the 15,000 foot mark. Furthermore, progress in drilling technique now permits accurate control in sinking curved holes to areas far out of plumb with the drill location, with highly ingenious methods of surveying the hole at depth.

C. Preparation or Concentration.

1. Adaptation of flotation methods to ore concentration, raising recoveries from 50 or 60 per cent up to well over 90 per cent. The enormous tonnage of copper now coming from so-called porphyry ores was made available only through these methods.
2. Use of selective flotation, in some cases combined with cyanidation and other concentrating methods, in effecting greater recoveries from complex ores. Large tonnages of zinc, formerly a deleterious or "penalty" constituent of many western ores, have thus become recoverable at a profit. Molybdenum averaging less than one pound per ton of ore is now being recovered as a by-product at the huge Bingham pit operation of Utah Copper Company.
3. Application of mechanical cleaning methods in coal preparation, yielding cleaner and more uniform products to meet more exact specifications prevailing in a highly competitive market.

These are only a few outstanding examples to illustrate the tremendous strides made by the mineral industry in conjunction with equipment manufacturers—all tending to make more minerals available and to increase recovery efficiencies at present operations. And progress continues. A radically new method of effecting a rough initial concentration at low cost by means of a differential density cone, for instance, is now receiving the last perfecting touches and will soon be headline mining news. Use of conveyors underground and in open pits is spreading, and trucks are taking over the work of heavy railroad engines and cars in hauling ore from many of the Mesabi iron pits. More complete cleanup of the pit may be accomplished in this manner—another victory for the conservation movement.

Elimination of Waste

Indictment of various branches of the mineral industry for anticonservational practices has arisen chiefly from losses or waste incurred in mineral extraction. It has been estimated, for example, that the average loss in recovery of coal is 35 per cent, 20 per cent being allegedly avoidable and 15 per cent unavoidable. Recoveries of petroleum average only 50 per cent under efficient practices, and the figure may drop as low as 10 or 20 per cent where proper back pressures are not maintained. Cases of enormous wastage of gas are replete in the literature. Illustrations of losses in metal mining are not as striking or numerous, but undoubtedly sizable amounts have been lost through failure to effect complete

pillar recovery in certain types of mining, and through selective mining of higher grade material under pressure of lower prices, with concomitant loss through caving of lower grade ores.

In citing these facts, however, it should be emphasized that all these losses have not arisen from outright profligacy or carelessness. Hydraulic backfilling of partially worked out coal beds, for instance, permits virtually complete recovery of coal pillars, as is practiced quite generally in Europe; but under the highly competitive conditions obtaining in the United States coal industry, such costly methods are virtually prohibitive. Likewise, a large proportion of the most flagrant cases of gas wastage took place before research had disclosed to the petroleum industry the vital function of gas in maintaining reservoir energy to prolong natural flow and effectuate more complete recovery. So far as base metals are concerned, systematic extraction in a single operation of low as well as high grade ore may be eminently desirable; however, high and low grade are decidedly relative terms, with prices and costs as the controlling variables conditioning their availability. No matter how uniformly high the price may be, there will still be marginal and sub-ores that must necessarily be left for possible later extraction.

Reduction of losses and elimination of waste in mineral extraction, however, remains the outstanding challenge to the mining and petroleum engineer. Conservation in its broad sense demands it.

Factors Giving Rise to Serious Waste

Fundamental factors which give rise to wastage in mineral extraction revolve around the highly competitive conditions in most branches of the industry, coupled with the fact that our productive capacity of many minerals is far beyond our normal peace-time requirements.

In the case of petroleum, the crux of the problem lies in the fugacious nature of oil and the court ruling that ownership of oil is established only when it is reduced to possession at the surface, regardless of whether it may have lain originally below the property of someone else. This is commonly known as the "law of capture." Ownership of petroleum leases is exceedingly scattered, and thus each operator is forced to protect his property from drainage by others. Usually, too, forfeiture of the lease would result if he failed to protect the interests of the lessor. Small wonder, then, that excessive quantities of oil are frequently produced and forced upon an unwilling market.

Similarly, our capacity to produce coal is far in excess of normal requirements. Our mines number approximately 6,900; ac-

cording to Rice [3] the average annual production per mine in 1935 was 54,000 metric tons in the United States; 112,000 tons per mine in Great Britain; 244,000 tons in France; 320,000 tons in Belgium, and 550,000 tons per mine in Germany. Thus, highly competitive conditions have arisen, aggravated by lessening markets due to the keen competition of oil and gas, and of hydroelectric power generated at huge government developments. Some 60 per cent of the total costs of producing coal go to labor, and organized labor has a firm grip on the industry, recently aided by assistance from Washington. For these combined reasons the coal mining industry as a whole has lost heavily for many years.

Conditions are not so intense in the base metal mining industries; but here, too, capacity has for many years been in excess of production. With large price fluctuations, many marginal producers operate at high prices and shut down when prices are low; this tends to amplify price movements, and opening and closing down of the mines are accomplished only at increased expenses for rehabilitation. If the peaks and valleys of prices and production could be levelled off somewhat, these losses might be minimized and selective mining, involving certain waste, lessened. However, consumption of the base metals is so intimately connected with the rise and fall of general business that stabilization could necessarily be made only partially effective.

Efforts to Improve the Situation

Efforts have been made with varying degrees of success both by industry and by the state and federal governments to bring about a more stable adjustment of mineral production to demand, and greater uniformity of price and production.

Voluntary Action.—Voluntary moves by industry to accomplish these purposes have been seriously limited by the anti-trust laws, more rigid enforcement of which has recently been pledged by the Department of Justice. Voluntary oil proration proved effective for temporary periods, but the dissenting minority interests invariably prevented continuation of the agreements.

Coöperative marketing agencies to accomplish stabilization in the coal industry received legal sanction of the U. S. Supreme Court in 1933 in the decision of the Appalachian Coals Case. Any test of the effectiveness of such organizations, however, has been screened by the efforts of the federal government to control prices and trade practices under the NRA and later under the coal control acts of 1935 and 1937. Formation of additional regional sales

[3] Rice, George S., and Hartmann, Irving, "Coal Mining in Europe"; U. S. Bureau of Mines, Bulletin 414, Washington, 1939.

agencies, permitted under the Guffey Act, has been pushed rapidly since minimum prices were suspended in 1938.

The risks involved in voluntary coöperation to effectuate stabilization were illustrated in the recent prosecution and conviction of a number of oil company executives argued at Madison, Wisconsin. The type of program adopted by the defendants in these cases had been previously sanctioned under the NRA code, and was carried out after the NRA demise as the result of general appeals by government officials to continue the major aspects of the NRA program as an industrial stabilization measure. Several retrials have been and still are being held, with a number of the original decisions reversed; but the entire litigation has proved exceedingly troublesome and costly to all parties concerned.

State Action.—Accomplishments of the states in furthering stability in the mineral industry have been greatest in connection with oil production control and conservation. Effective conservation laws are on the books in most of the larger oil producing states; and quotas for state, field and individual production are fixed by commissions in all principal producing states except California, where up to the present, stabilization has been accomplished with only partial success by a rigid gas conservation law and voluntary limitation of production. Agreements between the principal oil producing states, limiting excess production, have been effected through the Interstate Compact Commission.

Federal Action.—Federal action to stabilize the oil industry was initiated under the NRA, and following its invalidation in 1935 was continued through the Connally Act, prohibiting shipment of oil or oil products produced in violation of state regulatory laws. The United States Bureau of Mines continues to make monthly forecasts of motor fuel demand, and recommendations of crude oil production, by states, which will be needed to meet this demand. These are made simply as recommendations to the industry, and are not binding.

Federal regulation of the coal industry started with control of prices, labor conditions and marketing rules under NRA. It was continued on the same pattern by the first Guffey Act passed in 1935, which was declared unconstitutional by the Supreme Court in May, 1936, before any results from its operations were discernible. The second Guffey Act, omitting all labor clauses, was passed in April, 1937. Principal features involve establishment of minimum prices and marketing rules, which were promulgated in December, 1937, but were suspended two months later because correct procedure had not been followed in their establishment. Long delay in reëstablishing prices has followed, with the likelihood that further postponement will result from abolition of the Commission

and transfer of its functions to the Secretary of the Interior, to be effected July 1 through the President's Reorganization Plan No. 2. A strong segment in the coal mining industry is now pressing for amendment of the Guffey Act in many important respects, with stabilization to be effected principally through extension of the voluntary marketing agency plan under government supervision.

As an instrument for coal conservation, the main potentialities of the Guffey Act would seem to be in establishing the industry on a firm financial foundation, whereupon mining practices involving more complete recovery might be put into effect. Whether such a result can be attained in the face of oil and gas competition is subject to serious question. It will undoubtedly be some time before comprehensive study of specific conservation measures, authorized under the law, will be made. In the main, it can be said that the principal impetus behind the passage of the Guffey Act was to insure the status quo of coal mine labor rather than any concern over coal conservation.

In minerals other than oil and coal, a certain measure of voluntary control under federal supervision was exercised under the NRA codes for copper, lead, zinc and certain other minerals. Each of these contained fair trade practice and marketing provisions designed to help stabilize the industry; the copper code in particular provided for an elaborate set of sales quotas to be allocated to individual producers of both primary and secondary metal. With the invalidation of the NRA, of course, such practices again came under the purview of the anti-trust laws and were discontinued.

A few years ago the enactment of broad federal legislation covering all mineral resources was advocated, looking toward the balancing of supply and demand in the interest of conservation, by creating specific exceptions to the anti-trust laws under government supervision. This, broadly, was the recommendation of the Planning Committee on Mineral Policy. Subsequent thought, however, has turned toward specific treatment of individual industries; and beyond legislation affecting oil and coal, nothing further has developed. Interest now is tending to wane regarding the extension of regulation to other minerals.

Recently, considerable thought has been given to the formulation of a national energy resources policy, involving coördination of conservational programs with respect to all energy resources. A comprehensive report by the National Resources Committee on this problem is now in press. A summary report [4] was the basis of a special message of the President to Congress only a few months ago. Consolidation of petroleum and coal regulatory measures directly under

[4] "Energy Resources and National Policy—A Summary." National Resources Committee, January, 1939.

the Secretary of the Interior may be the forerunner of steps to fulfill these recommendations.

The possibility of outright nationalization of mineral resources, adopted by a constantly increasing number of foreign countries, seems rather remote, and is distinctly foreign to the history and traditions of the United States. It is my belief that any measures deemed necessary to conserve the mineral resources of this country should be such as to afford full scope to private initiative and enterprise, and should center on voluntary coöperation with only such exercise of governmental supervision as the public interest demands.

Legislation with Anticonservational Results

By and large, any legislation by either state or federal governments that gives rise directly or indirectly to higher production costs or lower selling prices will act as a barrier to best conservational practices, and in many instances will bring about definitely anticonservational results. Taxation stands out preëminently in this class, but other recent legislation is likewise important.

Mining is perfectly willing to carry its fair share of taxes, but does object to being discriminated against through higher rates than levied against other classes of property. This tendency to single out minerals for imposition of higher taxes undoubtedly springs from a concept that natural resources are a heritage of the people with special rights therefore attached to them by the public regardless of their private ownership. It fails to recognize the fact that most mineral deposits become valuable only through private expenditure (and frequent loss) of large sums in exploration, development, equipment, etc.

Special taxes upon minerals are numerous. In addition to the ad valorem and income taxes levied by many states, there are tonnage taxes, severance taxes, occupation taxes and royalty taxes. The ad valorem tax, collected annually by states on all minerals whether in production or reserve, is particularly prone to result in anticonservational practices. Its effects were summarized in the report of the Planning Committee on Mineral Policy as follows:

> Owners of mineral reserves are driven to open mines in order to provide income enough to meet their taxes, and the ad valorem tax has been one of the causes of overdevelopment of mine capacity, especially of the coal mines. It has a tendency to force selective mining with attendant loss of low grade material. It handicaps the orderly development and extraction of the miscellaneous grades to be found in most mineral districts. It puts a premium on the use of methods of extraction which cost the least, regardless of the fact that these methods often involve the permanent destruction or locking up of important reserves costing more to extract.

To a considerable extent the same effects result from other taxes, both state and federal, such as taxes and payments for social security, unemployment, old age benefits, workmen's compensation, etc., all tending definitely to increase production costs.

Sudden reduction in tariff protection may have a similar effect, through a lowering of the producer's margin as a result of price reductions forced by competition from the world market. The recent cut in the duty on zinc is a clear example. Effects of this have already been keenly felt in zinc mining areas—notably in the Tri-State District of Oklahoma, Kansas and Missouri. With such action already taken by the State Department with respect to one mineral, there is the constant fear that future agreements may seriously affect other minerals. Consequently, expansion programs looking toward future production are discouraged.

Similarly, limitation of working hours through the Wage-Hour Act has resulted definitely in making the most efficient production methods more costly, and has thus acted as a barrier to progress in adopting better conservational practices.

Costly labor disputes arising directly from unfair provisions of the Wagner Act and the biased administration of the National Labor Relations Board have in many cases disrupted coöperative relations between labor and management, and resulted in higher costs and lower efficiencies in mining operations.

Stringent regulations as to issuance of mine securities, while made to protect the investing public (actually a phase of conservation in a broad sense), have definitely slowed up and discouraged mine exploration and development. If known reserves of base metals are sufficient for only a few decades, it is not in accordance with conservation to discourage exploration for additional deposits, even though present productive capacity may be in excess of peacetime requirements.

All these features tie in generally with what may be termed the security movement. Your president, Dr. Karl T. Compton, issued a warning recently to the alumni of Massachusetts Institute of Technology, saying in part that the public and its leaders in their enthusiasm for the security program "may push this program beyond the limits which the present state of technology can support. If this should happen the whole structure of social security and high standard of living may fall like a house of cards. This danger, I believe, is very real. It can be combatted by two forces—first, a better education of the public and especially of its leaders to the realization of the necessity for keeping the demands of taxation and regulation within the limits which our technological production can support; second, the improvement of technological processes

themselves so that the increased demands for social security can be met by production and taxation."

This warning seems particularly appropriate as applied to this last phase of my discussion. On the one hand, steps have progressed considerably toward conservation of minerals, and on the other hand, costs are being heaped more and more on industry, including mining, to effectuate this broad security program, thus nullifying to a considerable extent what good may already have been accomplished.

The thought also is inescapable that there is somewhat of a paradox involved in the vital concern of Washington over the welfare of future generations with regard to maintaining their just heritage of mineral resources, while at the same time saddling the same generations in more or less reckless abandon with a staggering public debt.

But these discouraging features should not becloud in any way the path leading toward more effective functioning of mineral conservation, not in the sense that present reserves must be hoarded for future use, but that they must be exploited with a minimum of waste and put to most prudent use for the optimum benefit of both present and future generations. The mineral industry is coöperating in this program, and should view its responsibilities with even broader vision in the future. Government, on the other hand, should view the problem from all possible angles, and proceed with a sound program that will assure further progress through the exercise of a maximum of initiative in conjunction with only such degree of supervision as is necessary for the public good.

FLOOD CONTROL *

By W. E. R. COVELL, Lt. Col., C.E.

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The adoption of Flood Control as a national policy 3 years ago has brought the United States into a new phase of constructive national planning. It marks the entry of our government into conservation not only of our natural resources but also of our national resources. In addition to conserving our wealth bestowed on us by nature, we, as a nation are now building to save our homes, our industries and our lives.

When I speak of Flood Control I mean the prevention of serious damaging floods as contrasted with the control of ordinary high water. The Army Engineers are aiming particularly to cut the damage-producing crests from the floods that produce the greatest annual damages. A flood of the magnitude of March, 1936 causes widespread damage of very great amount, but it is of infrequent occurrence, so that the average annual damage from such floods is relatively small. The floods of small heights, although they have a high frequency, also result in relatively small annual damages. It is the floods of intermediate height, that is, neither extremely high nor just barely flood stage, that result in the greatest amount of average annual damages, since the damage per flood is relatively high and they occur fairly often.

The combination of circumstances that generally produces the highest average annual damages includes a sizable drainage area, frozen ground frequently covered by a deep snow blanket, rising temperatures, and heavy precipitation over a good deal of the watershed. Such an unfortunate coincidence of natural events produces floods today just as they produced floods long before any white man ever set foot on this continent.

In discussing this program of Federal Flood Control, I shall trace for you:

The development of the Federal Flood Control Policy.
The economic analysis and justification of projects.
The engineering methods of attacking any flood problem.
The actual application of these principles to the particular problem under my jurisdiction at Pittsburgh.

* Address delivered at the 47th Annual Meeting, S. P. E. E., June 19–23, 1939, State College, Pa.

And lastly, the actual results obtained from the first major project completed in my district.

The evolution of progressive legislative thought into a solid national flood control policy is an interesting study in itself.

Congress acted with determination in 1850, after the floods of that year and the preceding year had caused widespread damage on the Mississippi. It passed the Swamp Land Act, helping flooded states to build levees to protect themselves. It authorized also at the same time the first flood control survey in national history. The scope of the latter was confined to the delta of the Mississippi and was placed in charge of Captain A. A. Humphreys, Corps of Engineers, who in later years served with distinction in the Civil War and was Chief of Engineers from 1866 until his retirement in 1879. Captain Humphreys was assisted by Lieutenant H. L. Abbot, Corps of Engineers, who also served with distinction later in the Civil War, and after his retirement served on the American Board of Consulting Engineers to determine the plan of the Panama Canal. This work by two Engineer officers was the first extensive flood control study ever undertaken. Upon publication it was translated for discussion abroad. It is still considered a masterpiece among hydraulic treatises.

It was not until 1917 that another locality in the United States, the Sacramento River in California, received Federal attention in the form of legislation authorizing comprehensive flood planning for that watershed. But again the legislation was local and no national policy was yet established.

Ten years later, national planning on a large scale materialized in solid reality when the Corps of Engineers was directed to prosecute the well-known "308" surveys. These studies investigated the potential water power, aid to navigation, flood control, and irrigation utility of certain designated navigable streams and their tributaries. The resulting reports are known as the "308" reports, from the number of the House Document designating the streams.

These reports were a decade ahead of their time. When the Federal Congress suddenly decided to launch a national flood control and water conservation program, the Corps of Engineers was able to produce, on instant notice, extensive and well-considered studies upon which actual construction could be started with a minimum delay.

After the great floods of 1936, the first national flood control legislation was passed, the Omnibus Flood Control Act. This definitely established flood control as a national policy and authorized a large number of definite projects—all taken from the "308" reports and similar reports.

Under this Act, State and local coöperation for the construction of reservoirs was required. This feature was abolished by the Act of 1938 leaving the solution of the problem entirely in the hands of the Federal Government. However, existing policy in the Pittsburgh District, is to require prior approval by the State or States involved before design and construction are begun.

The adoption of a Federal Flood Control policy was the outgrowth of solid constructive reasoning and the realization that if the waters originating in one state cause damage to another or several other states, remedial action must come from an agency other than the states themselves. Quite naturally, therefore, the carrying out of a Federal policy fell to a Department of the Federal Government. And with an eye to the future, the operation and coördination of such a plan, if the greatest good is to benefit the greatest number, must also be a function of a Department of the Federal Government.

It was only logical that the burden of directing this policy should fall to the Corps of Engineers of the U. S. Army. Ever since 1824 the Corps has been developing our navigable waterways. And since 1850 the Corps has engaged in flood control in the several localities as Congress has from time to time directed. Surveys and plans for the Mississippi to control its flood rampages, flood damage studies that were incidental to the Corps' jurisdiction over navigable waters long before flood control as a problem attained national significance, and the "308" reports which inventoried the nation's principal streams and tributaries, all these, have endowed the Corps with the necessary and valuable background of experience for prosecuting such work.

The foundation of any conservation plan must be set on a sound business basis. The plan must be not only practicable, but it must be also justified economically. The conservation must cost less than the objectives to be attained.

The basic premise of flood control and protection reasoning is, therefore, since it is a form of conservation, that the annual charges of a project must be less than the annual benefits produced. There are many methods of flood control practicable from an engineering point of view, but only one plan can produce the greatest benefits.

For all of our planning of projects in the Pittsburgh District, the determination of benefits is the first step, since such procedure immediately indicates the probable amount of expenditure warranted and is therefore a guide to the extent of preliminary studies on any project. Thus, some projects can be early eliminated, from consideration, and greater attention devoted to more deserving projects.

In any consideration of flood protection benefits and assigning of values in dollars and cents, it is imperative that a set of rational

assumptions be advanced. This is not an easy task when one considers to what extent hydrological data differ for various sections of the country; to what extent the various areas of our nation have been subjected to industrial concentration and habitation.

We have found, in the Pittsburgh District, that the most equitable and rational method of evaluating flood damages consists in the following procedure:

We first determine the average annual direct damage prevented by the proposed flood control works. This is obtained by an analysis of past floods of record combined with a damage curve based on present values. In Pittsburgh our records are reasonably detailed and complete and extend over a long period of time. Therefore, we obtain this figure by summing the estimated damage resulting from all floods of record and dividing by the number of years represented by the record.

To the average annual direct damage thus obtained, we add an "assurance" factor, in order to reflect the value of the security created. This assurance factor is influenced by the degree of protection afforded by reducing the risk against floods greater than any which have yet occurred. As an illustration, it is possible to estimate the direct damage that would result from the maximum flood which could be reasonably anticipated. This figure could be used as a measure of the "assurance factor" by dividing by the expected life of the project.

To the total of the above, we then apply a percentage representing a factor covering future appreciation of property and values obtaining at the mid-life of the project. This factor is based on reliable statistical data reflecting the change in the dollar value together with the growth of the community. Such data are available at various governmental and private research agencies.

However, we cannot forget the indirect benefits, those gains which although more or less intangible, are very much in existence. We include under such items, these: The elimination of fire losses, usually experienced and sometimes beyond means of control at times of floods, improved sanitary conditions resulting in better health protection, safety of life, restoration of property values, and many others.

The extent and importance of indirect benefits cannot be overestimated. Their significance can be appreciated somewhat, I believe, when I tell you that the March 1936 flood in Pennsylvania, according to the State Department of Health, disrupted the service of about one hundred waterworks having parts subject to inundation. The floods adversely affected public waterworks supplying two hundred communities and about two million consumers. Of

these consumers about one and one-half million dwelt in the Ohio River Basin. Three large waterworks serving Pittsburgh and its environs have one million consumers.

Furthermore, main lines of railroads serving large and highly populated regions, are frequently paralyzed because of tracks and yards being subject to inundation. River traffic also is at a standstill during a serious flood. In times of a national emergency, such an unfortunate situation would hopelessly cripple our national defense.

For the efficient evaluation of benefits we have subdivided the areas subject to flooding into damage districts with each district referenced to a river gage, usually located within the district. We have covered the appraising of damages resulting from the relatively recent high floods, by detailed canvassing in the field, particularly in the larger damage districts, the heavily industrialized and populated districts. High water profiles are constructed for each flood, and the floods are then outlined on the various available maps. The outlined areas are thoroughly covered and accounted for with respect to flood damages for the major recent floods. My office is equipped to cover any and every subsequent flood in a similar manner.

Our methods of economic analysis comb out the undeserving projects and insure that the most meritorious projects receive the first priority.

As I have already mentioned, the engineering feasibility of methods of protection is considered hand in hand with the economic justification. The greatest impetus is given to the latter, however, because we can thereby curtail expenditure on investigation of a project the instant it appears to offer an unsound investment.

Of the various methods of flood protection, no one plan is best. Contingent upon various features of a locality that has a flood problem, the designing may be suggested by a number of methods, chief among which are diversion, channel improvement, protective wall or dike, detention basin, and storage reservoir.

Diversion affords perfect flood control where feasible by simply shunting the flood waters completely away from the threatened area. Diversion can either be internal, in that the diverting is somewhat localized and the waters remain within the drainage basin of the threatened area; or they may be external, in that the waters are transferred to an adjacent drainage basin.

An external diversion project on Lake Chautauqua is being studied at present by my office for the protection of Jamestown, N. Y. This plan would divert the excess flood waters of the lake basin into Lake Erie. An interesting by-product of this plan of protection of Jamestown would be the reduction of flood heights on the

Ohio and Allegheny Rivers since the Chadakoin River, the outlet of the lake, is a tributary of the Allegheny.

Channel improvements consist of widening, deepening, straightening and lining operations to permit present inadequate channels to carry high flows, with benefits intensely localized, as a rule. Johnstown, Pa., the scene of America's worst peace time disaster, is being protected at present by a channel improvement project at a total estimated cost of $7,600,000. It is interesting to note that during the preliminary studies for the protection of that city, a reservoir plan was considered for Johnstown's protection. It was found, however, that because of the small drainage area of 657 square miles above the city and the consequent limited number of feasible dam sites, a plan of reservoir protection would have given only one-half as much protection and would have cost almost three times as much as the channel improvement plan. Hence, the choice of the latter.

The economic ratio of benefits to costs for the Johnstown channel improvement plan as finally adopted is 9 + to 1, which is unquestionably the most favorable ratio for any major project in the United States.

Protective walls or dikes are another means of flood protection. They too produce benefits which are more or less local in scope, and must usually be of considerable height to be effectual and economically justified. Furthermore, they interfere, quite seriously at times, with local transportation problems and sanitary sewer and storm drainage facilities.

This method, however, has its proper place in flood protection. The levee system in the Mississippi Valley has grown to be one of the greatest flood protection systems in the world. During its development, there has been a continuous improvement of the whole so that when the great flood of January 1937 occurred, the flood waters passed to the Gulf without a single accident to the main system. As a direct consequence of the growth of the levee system, the alluvial valley of the lower Mississippi River has been converted from a great stretch of unproductive swamps to the most fertile and largest productive area in the world. Without a doubt, protection against floods on main streams involves consideration of protective walls or dikes. To what degree, however, is matter for economic study and consideration of what benefits might accrue from headwater reservoirs, if any.

Still another method of flood protection involves detention basins with dams whose outlet works are constantly open. The outlets are so designed that under reservoir-full conditions, the discharge capacity of the stream below the dam is not exceeded. Detention basins are of course relatively cheap and automatic in operation. On the other hand, however, future conservation of water consistent

with flood control uses, is somewhat limited. The fact that such a system of detention reservoirs may mean full protection to the citizens of one valley does not necessarily mean, however, that any benefits at all will accrue to the residents of another valley to which the first is tributary.

The method of flood protection adopted generally for the benefit of the upper Ohio River valley, and especially Pittsburgh, consists of a system of storage reservoirs. The dams will all have controlled outlets and will be capable of storing several days' rain. Release of stored flood waters, of course, will not commence until assurance is had that no damage will result in the valley below the dam.

By designing storage reservoirs for flood protection, it is frequently possible, without conflict with flood control uses, to make conservation plans at the same time for wild life, recreation and water supply. It is also possible to alleviate dangerous pollution conditions in streams below the dams by releasing storage during low-flow seasons. Many valuable by-products can thus be reaped from the use of storage reservoirs whose primary purpose is flood control.

The Tygart River Reservoir, which will be discussed in greater detail later, serves to illustrate the tremendous capabilities of storage reservoirs. This structure is the initial unit to be completed in the reservoir system for the protection of Pittsburgh and the Upper Ohio River Valley. The reservoir is designed with but little effect on its flood control value to provide an adequate low-water discharge for navigation purposes on the Monongahela River.

Before turning to a discussion of the plan of flood protection for Pittsburgh, allow me to repeat that flood control must be sound both in engineering and economics. It may be possible to protect a locality in a number of ways, but there will be only *one* plan that will be feasible to build and yet at the same time produce the maximum benefit per dollar invested.

To turn now to the specific application of flood control methods to a definite problem. The Flood Control Act of 1936 authorized a project for the Ohio River basin, of which one feature was a reservoir system for the protection of Pittsburgh and which will now be discussed in detail.

Pittsburgh lies at the junction of the Monongahela and Allegheny Rivers which come together at the "Point" to form the head of the Ohio River. Of the two main streams above Pittsburgh, the Allegheny is the most precipitous, whereas the Monongahela has the steepest tributaries. The total drainage area above Pittsburgh is 19,117 square miles, of which 11,733 square miles belong to the Allegheny. Pittsburgh, therefore, is very unfortunately situated in the late winter and early spring when circumstances bring to-

gether on a good portion of this huge drainage basin, frozen ground, a deep snow blanket, rising temperatures, and heavy rains. Such an unhappy set of circumstances can produce, as happened in 1936, a discharge at the "Point" of 557,000 c.f.s. where a discharge of 27,000 c.f.s. normally flows.

Since 1854, the year of the beginning of continuous records, Pittsburgh has suffered 93 floods or an average of 1.1 per year. (Flood stage at Pittsburgh's "Point" is 25 feet on the present gage; normal pool gage height is 16 feet; a "flood" at Pittsburgh is a stage greater than 25 feet.)

After consideration of all the feasible means of flood control it was decided that the best and most economical solution was a system of large storage reservoirs to be located in the Allegheny-Monongahela River basin.

The total capacity of the project system, including the Tygart Reservoir (which is the first reservoir), is about 2,300,000 acre-feet and the total drainage area controlled is 8,560 square miles, or about 45 per cent of the drainage area above Pittsburgh.

Present estimated total costs of the entire project, including the Tygart River Reservoir, is somewhat over $100,000,000.

The reservoir plan for the protection of Pittsburgh is designed to reduce the project flood, or 51.4 feet, to about 41 feet; reduce a 38.5-foot flood similar to that of March 1907 to 30.4 feet; a 34.3-foot flood similar to that of January 1913 will be reduced to 27.2 feet, and a 46-foot flood similar to that of March 1936 will be reduced to 38.3 feet. Slightly reduced benefits resulting from the reservoir system would also extend down the Ohio River to and below Wheeling, West Virginia.

Plans at present contemplate, where possible and without detriment to flood control, to reserve in some of the larger reservoirs having non-acid inflow, a part of the total capacity for water conservation for the dry months. This is of tremendous value in this area where domestic and industrial wastes present such a tremendous problem. Sudden fluctuations in acid content and peak loads of acidity place a huge economic burden on not only the metropolitan filtration plants but also industrial plants. There is also a distinct element of health menace. It has been estimated that at least 1 per cent of the total population of the United States and its territories could be beneficially affected by the proposed delivery of the added amount of good water.

It will be possible to have minimum elevation pools of considerable size in the reservoirs having good water, stocked with fish and the areas with wild fowl. Both boating and camping can be easily developed in season. We are thus producing by-products, as it

were, whose intangible worth might some day conceivably pay as many dividends as the flood control investment!

The construction of the reservoir plan for the protection of Pittsburgh is moving ahead at full speed. Tygart River Dam has been completed and has been functioning as a multi-purpose flood control and navigation water supply dam for more than a year; Crooked Creek and Tionesta Dams are 50 per cent complete and a fine start has been made on Mahoning Dam, begun last March. Loyalhanna Dam will be undertaken this summer.

The third anniversary of Pittsburgh's greatest flood is not far behind and already 5 of the 10 dams to prevent another such disaster have materialized.

In addition to the reservoir plan progress mentioned above, Johnstown, Pa., is being protected by its seven and one-half million dollar channel improvement project, and Wellsville, Ohio, has been protected by a four hundred thousand dollar flood wall.

Because our reservoir system of flood control is now in the process of design and construction, I have spent a lot of time telling you what we *estimate* the benefits will be, what we *hope* the plan will produce when completed. And you no doubt sit back and question, perhaps, and rightly, how do we know? And you are right, because we don't know absolutely until the plan is complete and definitely in operation.

However, let us leave the realm of conjecture for a moment and consider one unit of the plan, a unit which has been in operation now for over a year. For it is only through a cold analysis of operating tests—actual performance—that the true value of a project can be evaluated.

We made a serious mistake in the early stages of design of Tygart Dam. And just now, in fact it could not have been until now, we are beginning to realize the enormity of that mistake. We underestimated the benefits that Tygart Dam would produce. We were far too conservative in predicting the return on the public investment in Tygart Dam.

Tygart Dam is the largest concrete gravity dam east of the Mississippi River. It contains 1,250,000 cubic yards of concrete and is capable of storing 314,000 A.F. of water. The cost of the entire project, including a relocation of one of the lines of the Baltimore & Ohio Railroad, was $18,500,000.

Of the total storage, 100,000 acre-feet are stored from April 1 to July 1 and released from July 1 to December 15, to insure navigation on the Monongahela River.

In October 1937 even before the dam was finished it acted as a detention reservoir and reduced a flood crest at Pittsburgh by 2.1 feet and prevented damages of $2,075,000.

The dam was completed and accepted for operation on January 1, 1938, and since then has been rapidly acquiring the title of the nation's Number One Flood Control Dam. On January 31, 1939, it reduced a 24.6 foot crest at Pittsburgh by 1.3 feet to 23.3 feet. On February 4, 1939, a natural crest of 27.4 feet at Pittsburgh was reduced to 25.4 feet or a reduction of 2.0 feet. From January 29 to February 12, 1939, total rainfall of 5.24 inches fell over the Tygart Basin producing a total runoff at Tygart Dam of 369,960 acre-feet which exceeds in volume that for any other fifteen day period in a 33 year period of record. Comparing this 1939 flood with the March 1936 flood on the Monongahela River, discharge measurements at Lock No. 4, Monongahela River, showed the 1936 peak at that point to be 138,000 c.f.s. The peak discharge at Lock No. 4 on February 4, 1939, was 120,000 c.f.s. but would have been about 150,000 c.f.s. without the effect of Tygart Reservoir.

On both January 31 and February 4, the crests at Pittsburgh would have reached damaging stages. On these two dates total damages prevented were $1,530,000, raising the grand total of flood control benefits for the first year of operations to over three and one-half million dollars.

Further, during the dry period from August 16 to September 12, 1938, a total of 204,000,000 gallons of water per day was released from the reservoir. In the upper Monongahela River, the discharge from Tygart Reservoir was responsible, on an average, for about 70 per cent of the total discharge during this dry period.

The effect of the Tygart Reservoir on the maintenance of navigation in the Monongahela River during that period was very apparent. A head of approximately 0.5 foot was kept flowing over navigation dams Nos. 8 to 15 inclusive. At dams No. 5 and No. 6 the pools receded very nearly to the crest of the dam in late August and early September because of the greater number of lockages at these points. Without the increased discharge provided by the Tygart Reservoir, these pools would have fallen below the crests of their respective dams, the required navigable depths could not have been maintained and navigation would have been seriously impaired,—a serious situation, when it is considered that in some months Monongahela River tonnage exceeds that for the Panama Canal. The river serves the region which has been called "The Workshop of the World." Pittsburgh, as you know, is the greatest iron and steel center in the world, its pre-eminence based largely on the splendid navigation facilities provided by the Monongahela, Allegheny and Ohio Rivers.

And last year was not a particularly dry one. Only nine years ago the upper Monongahela River was so dry that it was possible

to walk across many of its pools. Benefits to navigation at times like those will amount to huge sums.

As a direct consequence of the added water the hardness of Monongahela water was reduced 23 parts per million, while acidity was reduced 6 parts per million. Nearly $600 per day were saved during this period by municipal filtration plants and industries along the river. Communities as far down the Monongahela River as McKeesport, Pa., 135 miles below the dam, benefited directly and substantially by this release.

These, and many more by-product benefits not included in the original economic evaluation of the dam, have become apparent during the past year. The Bureau of Navigation and Steamboat Inspection stated that

> "less trouble was experienced with boilers in the Pittsburgh District in the summer of 1938 than in any time during the past 21 years, due to the improved water conditions created by the release of purer water from the Tygart Reservoir during periods of low water."

Sanitary conditions have also improved proportionately and a serious polution problem is on the road to being materially improved. At Morgantown, W. Va., on the Monongahela River, 51 River miles below the Tygart Dam sportsmen reported catching over 150 bass ranging in size from 10 to 16 inches "for the first time," as one fisherman stated "in a generation." The significance of this catch can only be appreciated by a glance at the status of aquatic life in the river before the rapid industrialization of the Monongahela Valley. So many fish were killed in those years by the pollution incident to mining operations and industrial activity that lockages of dead fish alone were necessary all the way down the river to keep it open.

Regarding the reservoir itself, the West Virginia State Conservation Commission intends to utilize the water behind the dam to increase the acreage of fishing water in West Virginia. In 1938 the Commission stocked 500 large mouth bass in the reservoir and further proposes to experiment with the stored water to the extent of several thousand fish of different varieties until more can be learned about the body of water and its marine life potentialities. Local residents of that area have already reported extensive catches of blue gills during the summer of 1938.

A fair estimate then of all benefits attributable directly to Tygart Reservoir would approximate $4,000,000 during its first year of operation. Not a bad return on an investment of $18,500,000! Extremely fortunate perhaps, but none the less true. Tygart Res-

ervoir is helping to conserve our national resources far beyond expectations.

In the flood control design work in my office, we have been fortunate in having the aid of many of the ablest and most experienced consulting engineers and geologists in the United States. To their valued assistance we owe much credit in the vigorous prosecution of Federal flood control.

This Federal flood control program can go hand in hand with the development of land resources, reforestation, and measures for the prevention of erosion and water conservation in general. It is very seldom that major flood control structures conflict or interfere with other water uses. The Army Engineers, I can assure you, stand ready to coöperate to the fullest with any other agency, be it Federal or State or local, in the furtherance of ideas and plans on conservation programs.

MINUTES OF THE SECOND SUMMER SCHOOL FOR CHEMICAL ENGINEERING TEACHERS

Pennsylvania State College, State College, Pennsylvania, June 23–30, 1939

Since the papers are voluminous, copies are in the files, and the material is to be published by the Projects Committee of the A. I. Ch. E., there will be no attempt to summarize the subject matter in these minutes. This report will be restricted entirely to a brief recording of the discussions.

Friday, June 23, Afternoon Session

H. P. Hammond, Penn State, opened the meeting with a resume of the life and work of the S. P. E. E., indicating the formation of special divisions and summer schools. He disclaimed the position of Director of Summer Schools, abolished in 1933. His talk concluded with a warning against too great a specialization which might well mean no general engineering education and narrow graduates.

Kintner, in response, told how the necessity for funds for normally sponsored summer schools resulted in their abolition in 1933. The arrangements for this meeting were made privately, all expenses to be met by the small registration fee ($3.00) charged to each member.

A. B. Newman (C. C. N. Y.): "Teacher Qualifications."

Discussion.—Approval of this paper was so immediate and complete that the author promised to make mimeographed copies available before the end of the meeting. This was subsequently done.

Early discussion centered around the point of relief of administrative duties. Shreve wished to know how to avoid such a situation but no answer was forthcoming. Molstad thought that some such work might be essential and not too time-consuming if intelligently and thoroughly handled without repetition. Newman disagreed on the ground that teachers, not being qualified for such work, are wasting time on it.

In reply to Kintner, Newman added that a full-time mechanic is essential. Coons (Alabama) requested that such statement be added to the paper.

The elimination of routine duties, particularly as shunted to younger men, was discussed by Koehler (W. Va.), Kintner, Mc-

Cormack (Armour), and Withrow (Ohio State), with Newman emphasizing the need for the elimination of such a situation.

McCormack and Newman described difficulties involved in getting specialists from industry, to whom teaching is not a broad subject, but the narrow field with which they have been concerned.

Keyes (Illinois) suggested the method of industrial support and fellowships as a means of avoiding the difficulty of obtaining funds.

After discussion of means of formal approval of the paper, and requests for publication, Kintner explained that subsequent publication of all material presented was to be provided. Since plans and approval of the method were not complete, no description was given at the time. McCormack, Lindsay (Texas A. and M.), and Vilbrandt (V. P. I.) were active in pressing for formal approval. Kintner explained that the division was not in session, so that resolutions might not be spread on our minutes.

Saturday, June 24, Morning Session

J. R. Withrow (Ohio State): "Chemical Technology."

L. K. Herndon (Ohio State): "Laboratory Courses in Chemical Technology."

J. O. Pence (Ohio State): "Lecture Courses in Chemical Technology."

No time for discussion.

Lawler (Carnegie Inst.): "Service Courses" (by Jones and Lawler).

Discussion.—Olsen (Brooklyn Polytech.), referring to remarks upon demerits for the use of poor English in engineering papers, examinations, and reports, requested information as to the men who determined the penalty. Lawler responded that the practice was originated in the metallurgy department, but had spread throughout the engineering departments. The lost points are imposed by the technical department. In the case of unusual inaptitude, engineering students are assigned to a special course for delinquents, this course conducted by the regular English Department.

Shreve wished to know the name ascribed to the general cultural courses described by the author, which had been described as a group effort, offered jointly by departments such as English, History, Economics and Political Science. The answer was "Social Relations." Withrow noted the need for extreme coöperation between departments.

Giesy (Newark College of Engineering) thought that the authors were unfair to a course in shop practice in describing it as manual. He felt that it was no more so than many elementary chemistry courses, but received the designation in that it was professional rather than scientific.

J. H. Koffolt (Ohio State): "Graphical Computations in Chemical Engineering Laboratory."

E. M. Schoenborn (U. of Delaware): "Graphical Computations in Chemical Engineering Lecture Courses."

Discussion.—Formal discussion was offered by J. Coates (L. S. U.). He described the use of graphical integration and differentiation in the construction of the T–S diagram, using enthalpy data, differentiated at constant pressure to obtain C_p, the result integrated graphically (C_p/T vs. T) to give S.

Announcement.—Kintner announced the completion of the arrangements for the publication of papers by the Projects Committee of the A. I. Ch. E. He explained that some time would be necessary in the editing, requesting patience.

Saturday, June 24, Afternoon Session

E. L. McMillen (Lafayette): "Introductory Calculations."

P. F. Bruins (Brooklyn Polytech.): "What Calculations for Freshman Year."

E. E. Randolph (N. C. State): "Introduction to Chemical Engineering."

E. E. Litkenhaus (U. of Louisville): "Chemical Engineering Calculations."

Discussion.—There was considerable criticism of early calculations before a thorough grounding in physical chemistry, chemistry and physics had been obtained. Duplication of effect was the general opinion. Crawford (R. I. State), Rushton (Virginia), Kintner, Boarts (Tennessee), Morgan (Florida), Elgin (Princeton), Nickolls (Oklahoma A. & M.), and McMillen were active in the discussion.

Baskervill (Tennessee) asked for an exchange of problems to avoid the accumulation of answers in fraternity files. Elgin replied that that was being done by the A. I. Ch. E. Projects Committee at the present.

Porter (U. of Missouri) was very appreciative of the papers, particularly of the part about teaching of the slide rule. He wanted to know how much time was allowed for such an extensive course as outlined by Randolph, to which the answer was one afternoon per week.

MONDAY, JUNE 26, MORNING SESSION

J. H. Rushton (Virginia): "What may be Covered on Fluid Flow in the Time Available."

E. M. Schoenborn (U. of Delaware): "Types of Laboratory Work and How Best to Correlate them with Class Work."

R. M. Boarts (U. of Tennessee): "How Best to Tie Up Actual Performance with Theory for the Various Measuring Instruments."

Discussion.—The first question was the possibility of work of the nature described by Boarts being included in a regular laboratory course. To Koffolt's query on this point, Boarts pointed out that the work was done by coöperative students who seem to have more energy and interest than regular students.

Crawford noted that, although industry uses many instruments, it is rare that a laboratory can afford them. Rushton and Ragatz indicated that an essential difference is to be noted between fluid flow and instrumentation.

McCormack suggested that all experiments are not sure to check the theory. Valves and roughness of pipe should be included, although they rarely are. Rushton added that there is very little data for old pipes. Colburn suggested the failure to check a theoretical line is not always a fault, since the data may well check that of another experimenter, whose conditions may be duplicated. Coates felt that no work on the checking of theory is any good unless it involves every variable separately. He attributed the failure of Webber (Iowa State) to get heat transfer-fluid flow correlation to lack of segregation of all variables.

Masson (N. Y. U.), Gardner, and Giesy advanced a plea for a study of precision of measurements in laboratory work. Work (Columbia) asked for inclusion of study of economic pipe diameter.

T. B. Drew (duPont): "The Teaching of Heat Flow."

Discussion.—Drew expanded upon the point of the temperature distribution in a long tube, showing how it must vary from end to end, in response to Koffolt. In the matter of factors of safety, he explained to Baker (Northeastern) that the practice varied; for clean organic vapors, the lowest factor is used, 10 to 20 per cent, for the Nusselt formulae are on the safe side anyway; typical factors are more nearly 25 to 30 per cent. At Colburn's (U. of Del.) suggestion, Drew told of the publication by The Heat Exchangers of very excellent fouling factors. He added that in designing calendrias for organic liquids 300 to 400 per cent error is a very good estimate.

Colburn asked for information on small heat interchangers. Drew replied that the Andale Company, Philadelphia, make an excellent CI shell, bronze tube sheet, model, selling for about $30 The model is a perfect replica of larger units.

A. P. Colburn (U. of Delaware): "The Teaching of Absorption."

Discussion.—Higbie (U. of North Dakota): The analogy of heat transfer to gas absorption is not perfect, but may not affect the mathematical analysis. Colburn responded that this is much the same thing that Drew describes of heat transmission.

A general analysis of the performance of packed columns and correction for free space under the packing followed, in which the participants were Colburn, Koffolt, Kintner, Baskervill, Crawford, Webber, Coates and Agapetus (U. of Colorado).

Satisfactory systems for study were stated to be acetone-water and alcohol-water by Coates and Webber respectively.

In this group of papers was C. L. Mantell's "Adsorption," read by Hougen. This elicited the question from Colburn as to whether anyone had made comparisons (in plant design courses) of the relative costs of acetone removal by adsorption, scrubbing-distillation, and compression. Molstad showed that the costs may well depend upon concentrations. Comparisons could only apply in low ranges. He confirmed Hougen's remarks on the need for rate data. Isothermal adsorption is not easy. Withrow, Webber and Horton (L. S. U.) participated in the discussion.

Elgin expressed the opinion that adsorption is interesting in being a case of purely one film. The rates are not infinite although the texts are prone to say so. In answer to Hougen's question as to whether anyone had successfully handled rate studies, Wilhelm (Princeton) explained the extent of his work on the subject, using gels coated with $CoCl_2$ as indicator. Work showed that temperature difference being important, the subject is inclusive of flow through beds of packed solids, and thus depended upon thickness.

MONDAY, JUNE 26, AFTERNOON SESSION

L. T. Work (Columbia U.): "The Teaching of Classification and Size Reduction."

Discussion.—Work concurred with Koffolt that the Federal air separator is not satisfactory for analysis. He discussed the Re-ψ lines with Giesy. To Faith's (Kansas State) question on addition agents he stated that they may prevent clogging, helping in some general way.

Work's opinion for student laboratories is that trap rock, mica, and limestone are best. Fibrous materials are hard to analyze and

usually handled only in hammer mills. Jaw crushers, rolls, and ball mills seem best for student work, the last being favored. These statements were the result of questions from Nicholls and Agapetus. Cryder did not have data on their small Hardinge with feeder. Work wondered if it were possible to stabilize the unit in a laboratory period with two different circulating loads. Withrow added problems on recirculation. He also pointed out variations being possible from the published grindability figures for which Work thanked him.

Masson's request for information on moisture content effect brought the answer that all grinding should be done completely wet or completely dry, moisture effects being best represented by the data for coal.

Koffolt and Leubbers (U. of Missouri) discussed the measurement of power to machines, the latter telling of measuring with watt-meters, ammeters, and voltmeters with a 2 per cent accuracy, and showing that 90 per cent of the increase over the idle consumption may be useful.

Webber spoke of difficulties in settling. The dispersion medium may be very important.

W. L. Badger (Dow Chemical Company): "Evaporation."

Discussion.—In response to the questions by Coons, Morgan, Kintner, and Koffolt, Badger answered specifically as follows:

He could see no advantage in the horizontal, forced-circulation evaporator.

There can be no price for exhaust steam. This is an individual proposition. In every case, it is necessary to take the plant as a whole and balance costs as a whole for each alternate method of operation.

Velocities of 8 to 10 feet per second will not be sufficient to completely eliminate scaling of an inverted solubility salt. To the speaker's knowledge nothing is known as to the possibilities of minimizing scale by the use of metaphosphates. Shreve participated in this discussion.

There is no minimum size for an evaporator for teaching purposes. However, it is advisable for the unit to look like an evaporator used commercially. For research purposes, anything that will do the job is satisfactory.

There is no known way to measure velocities in evaporator tubes other than to measure the rate of evaporation.

Crawford agreed with the speaker's remarks on the need for student knowledge of methods of handling and fabricating materials. He stated that his institution had just bought an experimental evaporator, about which he would be glad to confer with anyone interested.

TUESDAY, JUNE 27, MORNING SESSION

G. G. Brown (U. of Michigan): "The Teaching of Distillation."

Discussion.—Koffort requested information as to the amount of time to be allotted for distillation in an undergraduate course, and as to the speaker's opinion on the use of the laboratory for bringing home the points chosen in the lecture course. Brown replied that he did not teach an undergraduate course, but that he should imagine that one-third of a term was proper. As to the laboratory, there is no substitute for it in the demonstration of theoretical considerations. The laboratory at Michigan is largely conducted in shift work (due to the huge evaporators, which must be operated at least 24 hours) so that Colburn's question on the set-up for a continuous run without too many time-lag factors is not important there.

Brown does not believe that "trick methods of calculation," such as Randall's need be included in an undergraduate course. This opinion was in reply to Webber.

Coates and Molstad asked for more information on retrograde condensation. Brown redefined it as "condensation taking place at constant temperature with decreasing pressure." A demonstration apparatus may be designed using a complex system. The critical point shows a deep mahogany color, probably an optical phenomenon.

Gardner, Nicholls, Kintner, Brown, and Hougen discussed the methods of teaching distillation with regard to the relative position of other unit operations and to the inclusion of Ponchon and McCabe-Thiele diagrams. Brown preferred absorption, stripping and fractionation for graduate work order but admitted that it might not be practical for undergraduates. Nicholl stated that he had used that order this year but intended to precede absorption by distillation in the coming year. Brown wanted neither diagrammatic method omitted but agreed that Ponchon is the best introduction since it does not involve the assumptions necessary in the McCabe-Thiele method.

To Agapetus' question Brown added that ternary systems were really multicomponent, a designation which he preferred to maintain.

Faith asked what provision was made for columns (such as esterification columns) in which reaction occurred. Brown replied that these are not really unit operations.

Boarts knew that Michigan had some very excellent films of distillation which he hoped might be edited, reprinted, and made available to all schools. Brown thanked him for the suggestion.

McLain (U. of Arkansas) was referred to McCormack's afternoon session for information on laboratory columns.

R. C. Ernst (U. of Louisville): "Laboratory Drying Experiments."
A. B. Newman (C. C. N. Y.): "Theoretical Aspects of Drying."
O. A. Hougen (U. of Wisconsin): "Drier Calculations and Design."

No discussion.

Tuesday, June 27, Afternoon Session

H. McCormack (Armour): "Laboratory Equipment."

Discussion.—The greater part of the discussion dealt with thermocouples. Faith, Koffolt, McLain, Coons, Morgan, Webber, Cannon, Gardner, Baskervill, and Lindsay contributed. McCormack described his improvement in the radiant gas couple of Barr and Berger to eliminate threads. The error produced by failure to use specially designed couples for gas streams was stated to be as much as 300°. All thermocouples are calibrated in place, but not by the students, whose calibration experiments are on couples not used on equipment. The accuracy of the chromel-alumel couples is to within 2°. A special type of installation which has been successful was illustrated for standard pipe and flat plates. It is not found necessary at Armour to include mixing cups for obtaining true oil temperatures. If the top of the cross section of the tube be designated as 0° and the bottom as 180°, the best position for the true pipe wall temperature by thermocouple, in condensation experiments, is 87°, although insufficient data have been obtained for a reliable statement. A single common lead to a series of couples is not unreliable.

Faith asked if the gas fired furnace described might be replaced by an electric furnace. McCormack has used such a unit and still does on occasion.

Colburn added that Sherwood has found that a calming section to a condenser is unnecessary (produces no change) and is inconsistent with industrial practice of tube bundles. If it is desired to obtain a heat balance on a condenser, utilizing an outer glass jacket, a trough may be placed under the condenser tube for the true condensate.

Wednesday, June 28, Morning Session

J. C. Elgin (Princeton): "The Teaching of Solvent Extraction."

Discussion.—Fenske: Triangular diagrams are really the province of the physical chemists, but a great many more systems are

necessary. If the chemists do not produce them, it will be up to the engineers to fill the need. In this connection, tie lines must be included as well as the equilibrium data. It would be very advisable to standardize the units in which the diagrams are represented.

Laboratory experiments to show similarity of many unit operations of this type are desirable. Apparatus for distillation is well standardized, but no one knows how to build a large scale extraction unit. For the laboratory, glass aids visual teaching; the Sohxlet apparatus is analogous to the Rayleigh equation. But at all costs, the *fundamentals* must be taught. More complicated apparatus may be of a graduate nature.

Colburn (requested discussion): Fenske's point of the need of data is strongly stressed, a long range job. It would be interesting to compare extraction and distillation. In the former only the activity coefficients are involved, while in the latter both these and the vapor pressures are important.

Cobleigh (requested discussion): Several systems for laboratory work were presented, leaching sodium chromate for plating solutions, leaching oxide for sulfide ores, leaching phosphates from ores with sulfuric acid, and the treatment of zinc ores as submitted for the laboratory handbook.

At Shreve's request, Fenske expanded Elgin's remarks on the use of reflux. If, in a mixture of A and B, A is more soluble in the solvent, all of A can be leached out, giving pure B; but, since B is leached out with A, A cannot be obtained pure unless reflux is used to free it of B, forcing the latter through the system to the B-discharge end.

W. L. McCabe (Carnegie Tech.): "The Teaching of Crystallization."

No discussion.

H. A. Webber (Iowa State): "Instruction in Filtration."

Discussion.—Green (Kansas State) (requested discussion): While a mathematical treatment should be taught, it must be remembered that the industrial manufacturers of filtration equipment do not use the filtration equations. Each sludge is different, with the necessity of experimental data.

Hougen and Morgan agreed that, since the manufacturers do not use the equations, the best methods for students require their knowledge of standard tests. Leubbers feels that the equations confuse the students upon first acquaintance, but that their confidence is quickly restored by the excellent agreement obtained in the laboratory. McCormack noted that there is no advance with pessimism; he has a lifetime job for a young man willing to spend

time on filtration. Confidence in the theories, or demand to expand them to produce such confidence is absolutely essential, and characteristic of all the other unit operation advances.

Replying to Gardner, Webber stated that the use of compressed air to move slurries depends upon their density, size, and concentration before assurance of satisfactory agitation may be certain. He added that the thinnest cake which will discharge freely from a rotary filter is the optimum thickness. On this subject, Morgan stated that the agreement of rotary filters with the theoretical equations is aided by the coating to the thickness of the wires before data are taken. Precoating may also be employed.

Wednesday, June 28, Afternoon Session

H. McCormack (Armour): "Laboratory Equipment."

Discussion.—Giesy, Shreve, Webber, Bruins, and Morgan discussed the column still with McCormack. Points brought out were that the still was continuous, that brass plates were soldered to the aluminum column, that constant reflux ratio may be obtained by division of a series of slot or circular weirs, the division being variable by the expedient of rotating the pipe containing the wier openings.

McCormack stated that although methanol-water and acetone-water were the mixtures that had always been used, search was being made for other binary mixtures, not inflammable. Fire hazard is prevented by the elimination of all flames from the building housing the columns. Green's questions elicited this information.

Molstad credited Rushton with the idea of using Excelso and Taco coil heaters for small preheating jobs. The former have replaceable coils. Both are very inexpensive.

McCormack answered Faith that there is no advantage in the eight inch size customarily found in university laboratories. He told Bruins that the column was heavily lagged to maintain constant reflux as nearly as possible, and provide for heat and material balances. Koffolt contributed.

Gardner, McCormack, Koffolt, Vilbrandt, and Morgan discussed the design of filter units for the laboratory. McCormack averred that the commercial units have grown up, not been designed. We should be designing the equipment for the manufacturers, not them for us. Vilbrandt disagreed with this statement in general, for much equipment on the market (although not in filtration) is the result of university research. This we do well to buy and adapt directing the greater part of our energies to other, more necessary, channels, McCormack concurred.

Kintner expressed the opinion that buying of commercial equipment is a waste of money. Laboratories are not bought, but grow. Vilbrandt agreed to a certain extent, but added that one "cannot start from scratch."

Higbie and Agapetus also contributed to these discussions.

THURSDAY, JUNE 29, MORNING SESSION

W. M. Cobleigh (Montana State): "Engineering Economy."

Discussion.—Shreve noted the extreme indebtedness of the Summer School for the breadth and depth of this paper. He wondered if we need six credit hours for our students in the regular economic departments. Colburn stated that the Education Committee of the A. I. Ch. E. prefers that the students be taught economy by economists. Giesy would like to see courses in the History of the United States and of the World, taught with respect to economic changes.

Molstad described the history of mechanical engineering indicating that saturation of the technical market for engineers results in their eventual placement in administrative fields. Looking forward on these lines indicates the need for engineering economy in chemical engineering.

Vilbrandt offered Perry and Cuno, *Chem. and Met.*, **41**, 439 (1934), to take the place of the bibliography on plant location, stated by Cobleigh to have been omitted by stenographic error.

T. H. Chilton (duPont): "Correlation of Experimental Data."

Discussion.—Errors of plotting one variable against itself, particularly if it is controlling, were noted by Hougen. Colburn emphasized the fact that dimensional analysis is not the ultimate in correlation work.

Giesy, Koffolt, Boarts, Crawford, and Chilton discussed the proper use of significant figures.

Gardner contributed a story of W. K. Lewis and the interpretation of experimental points.

Chilton illustrated a method which had been used by duPont in attempting to correlate pressure drops across tube banks.

Kintner and Brown contributed to the discussion.

R. A. Ragatz (U. of Wisconsin): "An Undergraduate Course on Instruments for the Measurement and Control of Process Variables."

R. J. DeJuhasz (Penn State): "Principles, Design and Operation of Engineering Instruments in the Engineering Instruction."

Discussion.—C. C. Monrad (Carnegie) (requested discussion): The basic job required of graduates is most important. That seems to be more in line of design of a process adaptable to instruments than selection of the final instruments. In that case we must teach what is available but *not* the details. Another important point is what to eliminate from present curricula if such a course is to be inserted. It can be offered as an elective, as at M. I. T.

Vilbrandt and Ragatz mentioned Leeds and Northrup, Brown, and Foxboro as instrument manufacturers who give courses in instrumentation for graduates. The U. S. Steel Corporation also has a course.

Brinker stated that the course at Pittsburgh, listed in Ragatz' paper has been discontinued.

Kintner noted that the inclusion of the subject in the Summer School program did not indicate the Advisory Committee's indorsement of its necessity.

Thursday, June 29, Afternoon Session

F. C. Whitmore (Penn State): "Graduate Programs."

Note.—Since the entire hour was used for general discussion, the summary below represents the entire period.

Whitmore opened the period with the question of the object of graduate study. Brown was of the opinion that there were two objects: first, producing masters; second, production of doctors. The latter are an entirely different class of men from bachelors and masters. They are primarily teachers and research men, necessarily firmly grounded in both the theoretical and applied branches of the subject. The masters differ from the bachelors only in having their knowledge better coördinated, so that they are worth $30 to $50 more a month to industry at the start. But they are performing the same types of jobs as the bachelors. It would be desirable to do the coördinating work in the undergraduate curricula, but since this seems impossible it serves a very useful purpose in a fifth year. Bachelors are probably not worth their salaries to industry in the first two or three years, but masters may take hold in six months.

Whitmore's next question dealt with the subject of first year graduate programs for masters and doctors, and the extent to which these should be similar. No definite answer to this question was forthcoming, although Brown stated that the parallelism was urged, but not required.

A protracted discussion of theses for masters ensued; that a doctor must do a thesis was taken for granted, but Brown stated

that the thesis was not required of a master at Michigan. For this work may be substituted a course in comprehensive problems. If the thesis *is* elected, it is a course matter, all theses being directed by one man. Cryder and Morgan suggested that, although the master has not time to complete an experimental program, it may be possible for him to do a complete portion. Crawford added that the numbers at Michigan undoubtedly led to the elimination of the thesis, but pointed out that it is a very important part of research programs at smaller schools. Brown concurred with these last remarks entirely. Giesy and Kintner suggested group experimental work with responsibility shifting from time to time. The expense of theses as a reason for their elimination in some institutions was suggested by Whitmore.

From the question of expense, the discussion turned naturally to industrial fellowships. Boarts expressed the difficulty of obtaining good unsupervised work for the industry donating the fellowship, coupled with the necessity of partly unsupervised work in order to develop the man. At Purdue, Shreve stated that the man received only half credit for industrial work, while Faith and Brown added that their men received *no* credit for such work. Whitmore believed that the last method is the best since in this case the results are the product and the man the by-product; in educational work exactly the reverse is true.

Discussion of the students qualified to do graduate work brought out the point that the utmost frankness in recommending a man to another institution is absolutely necessary. One can judge men with whom intimate contact has been made in undergraduate work, but must rely on opinions of his teachers when change of institution is involved.

It was agreed that the direction of theses should be by the best staff members, but that numbers usually made the inclusion of all imperative. Brown described the Michigan plan of committee direction.

Other participants in these discussions were Kintner, Vilbrandt, Borgman (U. of Colorado) and Chilton.

Friday, June 30, Morning Session

F. C. Vilbrandt (V. P. I.): "Coördinating Plant Design with Chemical Engineering Unit Operations Laboratory."

C. P. Baker (Northeastern): "Plant Design at Northeastern University."

C. W. Simmons (Lehigh): "Plant Design at Lehigh University."

J. W. Green (Kansas State): "Abbreviated Course in Plant Design."

Discussion.—Upon the request of Gardner, Chilton made the following comments: a general knowledge of the subject is undoubtedly valuable, including such material as waste disposal, air pollution, accessibility. Layout certainly should be taught, saving conveying and time. No concern builds its own filter or heat interchangers so that equipment design of detail is unnecessary. Economic choice of equipment is splendid practice. There is no answer to the question of individual or group work. Some group assignments favor industrial organization. Students may do parts of a problem and compose the result in groups.

Other discussion was of a very specific nature: the inclusion or exclusion of packaging and shipping; the extent to which students should get their own data; the emphasis on engineering drawing. Morgan, Simmons, Vilbrandt, Crawford, Koffolt and Coates contributed.

D. S. Cryder (Penn State): "Senior Projects."

Discussion.—M. C. Molstad (Yale) (requested discussion): No formal paper was presented since Dodge has already written on the subject (Proceedings of Fourth Symposium on Chemical Engineering Education, A. I. Ch. E., 1935, edited by Newman). 45 per cent of all Yale projects deal with unit operation equipment, usually their performance, some unit process work, and a few analytical and physical chemical problems completing the list. The students think that the course is valuable.

D. F. Othmer (Brooklyn Poly.): "Senior Problems at the Polytechnic Institute of Brooklyn."

H. Bunger and J. W. Mason (Georgia Tech.): "Senior Projects—*One* Department's Opinion."

Molstad answered Coons with the statement that some emphasis *is* given to the drawing of proper specifications for work to be performed by the machinist. No plant design, he told Shreve, is considered in the projects course; that material is taught in another term. Beisler (Florida) explained to Crawford that projects is an elective and usually reserved for the best students; they get their ground work in the first term.

Kintner voiced a definite objection to allowing students to erect equipment in their projects. Vilbrandt participated in the general discussion.

O. A. Hougen (U. of Wisconsin): "Comprehensive Problems."

Discussion.—Hougen was of the opinion that the discussion of this subject had preceded the hour assigned by being involved in many other topics. He answered certain questions: if combined

with the thesis, the design may use some experimental data, a very satisfactory combination; an 18-week, 3-hour course is conducted at Wisconsin, the lecturer treating *his* problem, the student applying this information to theirs; the design is not all embracing in the time allowed, the attack being more important; there is no graduate course in plant design at Wisconsin. Questions eliciting these replies were voiced by Crawford, Coons, Cryder, and Koffolt.

The meeting and Second Summer School adjourned at 11:45 A.M.

Respectfully submitted,

JOHN C. WHITWELL,
Secretary.

SERVICE COURSES IN THE UNDERGRADUATE CHEMICAL ENGINEERING CURRICULUM *

BY LEO T. LAWLER, Associate Professor of English, AND WEBSTER N. JONES, Director, College of Engineering, Carnegie Institute of Technology

Undoubtedly one of the knottiest problems which the chemical engineering educator has to solve is the choice and presentation of service courses in the undergraduate curriculum. The problem is made difficult by time limitations. The four years of the undergraduate training period are indeed short, even though we state our objective as preparation for the chemical engineering profession rather than the production of chemical engineers. It would, however, be unfair to ask more time from our students when we know, though they do not usually realize the value of their time, how valuable it really is.

In addition to the time limitations in the choice and presentation of service courses, there are also preparation limitations—limitations placed by early attempts to specialize the preparation of the students. In general for the profession of chemical engineering the functional industrial activities are research and development, production, marketing, accounting and finance, industrial and public relations, and administration. Add to these the utilization of the course as means to a general understanding of the current scientific and industrial social order and the training for the teaching profession. These are all so many more variables. If, for example, the student's interest be early centered in research and development, he will wish to equip himself for that

* Presented at the S. P. E. E. Summer School for Chemical Engineering Teachers, Pennsylvania State College, June 23–30, 1939.

work after completing his four years by taking such additional courses as will seem desirable in attaining his objective. These courses probably will be in his specialty. They might be service courses. The tendency, however, is to squeeze the previously ascertained service courses into the undergraduate four years with the probable result of detracting somewhat from the major interest. It is likely that there would be a similar variance evident in all the other functional industrial or general activities.

In considering the whole matter, we are asked not to forget a somewhat pragmatic injunction that we should prepare a student to do his job in order to insure his success and to earn his salary, in order to be fair to industry or to whatever other use he puts his training.

It is not uncommon to hear critics of chemical engineering education attempt to attribute its errors and omissions to the extreme youth of the profession. In comparison with the other engineering professions, it is young. This circumstance should be regarded favorably rather than unfavorably, for the profession should be able, during its formative period, to take full advantage of the experience of the older professions and to avoid their more glaring weaknesses, for example, narrowness.

These preliminary considerations in the approach to our topic, "Service Courses," indicate that we must look at our objectives in undergraduate chemical engineering training in the light of definite limitations in order to determine the character and extent to which these courses should be introduced. It is apparent that provision must be made for basic service courses; for others there must be some compromise. It seems logical that our analysis should also make clear the best possible economic use of the student's educational time in the attainment of the objective—preparation for the chemical engineering profession.

In 1922, early in its development, to quote Doctor Little:

> Chemical engineering, as distinguished from the aggregate number of subjects comprised in courses of that name, was not a composite of chemistry and mechanical and civil engineering, but itself a branch of engineering, the basis of which was those unit operations which in their proper sequence and coördination constituted a chemical process as conducted on the industrial scale.

Several years later this definition was expanded into a more positive statement and included the application of the principles of economics. In 1937 the following statement defined and amplified the objectives of the profession in the light of experience and growing needs:

Chemical engineering, based on the triple foundation of mathematics, physics and chemistry, is concerned with the development of processes and the design and operations of plants in which materials undergo changes in properties. In common with other divisions of engineering, chemical engineering is concerned with economic and human, as well as technical relations, and the mature engineer may become an executive, utilizing his scientific knowledge and professional experience to direct industrial enterprises.

It is interesting to see how the humanities—history, literature, economics, psychology—have thus become basic studies in the preparation for the chemical engineering profession. The change has been the product of external social pressure. The leaders in educational thought have realized the value and need for such studies in the workaday world. These courses have done much to insure the evolution of an educated man rather than the development of a high-powered instrument of production. They have done much to make the training broad, to encourage the critical attitude in the student, and to enrich his life. They constitute the difference between vocational and professional education, between a certification of courses taken and a bachelor's degree. The inclusion of them with the basic scientific study is the answer to the adverse criticism of the liberal arts and science stand-patters who frowned deeply on the narrowing trend of engineering education.

The need for the humanistic training being recognized, the next problem was their inclusion in the curriculum. At first there was a compromise. Some of these courses were put on the prescribed and some on the elective list. In several instances they replaced the service courses of lesser importance, such as typewriting, elementary accounting, and even shops. A solution to the problem of the inclusion of these humanities has recently been developed at the Carnegie Institute of Technology. The students are given training in social relations. Approximately one-fourth of their time is devoted to it. This training is a composite of the humanities. It includes economics, history, literature, and psychology. It does not consist in a smattering of each given for a brief period. It is not a survey or orientation course. As a matter of fact, course lines and divisions, which it must be observed, were originally devised for pedagogical purposes and which are in a way extraneous and foreign to the subject matter, have been obliterated. There is the further advantage here in the early presentation to the student of the interrelation of the studies. They become more integral in his culture. Economics and psychology are seen in history and literature and the arts, just as they should be, and just as we as educated men should see them.

In addition, there is a constant effort to interrelate these studies with the basic professional studies. There is sufficient time and course emphasis in relation to the objectives of the undergraduate to insure his attention. This work is not just something to pass or to get credit for in order to attain a degree, something to be endured while the real professional training is in the process of development. It is not something to be learned to be forgotten. It is a four-year course, one of enough length and sufficient proportions to command the student's interest.

The catalogue statement of the objectives and the course descriptions may aid in a better understanding of the whole program:

Its objectives are: (1) a clear historical understanding of the parallel growths of science and engineering, on the one hand, and social customs, relations, and institutions, on the other, and how these have reacted on each other; (2) social consciousness and historical perspective of social evolution, especially since the beginning of the machine age; (3) ability to read purposefully concerning problems involving social and economic elements in order to make critical analyses of such problems and to arrive at intelligent opinions about them; (4) ability to organize thoughts logically and with purpose; (5) ability to use the English language to express those thoughts effectively, both orally and in writing; (6) a continuing interest in all these matters and thus the desire to become educated.

This statement of objectives evidences the integrated nature of the course, especially of social studies to each other and to engineering training and practice. The work of presenting the course year by year is explained as follows:

The aim of the freshman program is to lay foundations for growing understanding of society and continuing interest in social relations. Phases of present-day society will be studied in the light of their interrelations, of their historical backgrounds, and of social changes of our time, with particular emphasis upon the mutual impacts of cultural, economic, and technological forces.

During this year the students will be introduced to the historical backgrounds of the machine age, the evolution of technical education, and the development of the use of communication media and educational tools. The work of the second year is a continuation of the first.

Building on foundations laid in the freshman course, work of the sophomore year aims to enlarge the student's power of analysis and to stimulate intellectual curiosity. Students are encouraged to pursue independent study of selected topics, especially such as involve the influence of technology upon social progress. In order to enlarge the student's

capacity for discriminating appraisal of social institutions and policies, some of the topics of study will offer training in the use of statistical and other tools of scientific analysis.

It may be said at this point that the basic principles of the several social studies will be presented at the most appropriate opportunity in the courses. For example, various economic laws will be explained and applied, and as indicated in the work of the sophomore year, the methods of using statistical data will be presented to the students. This matter has been the focal point of some criticism. The conservatives ask when and where the fundamentals of each study will appear. The answer is in the topic discussion which gives rise to their use. This elucidation and application of fundamental principles may be shown by reference to the development of the railroads in our country during the post Civil War period. This development necessitated capital. That subject alone involves an examination of sources and means of making capital available. To it, very logically, could be related monetary standards, corporate finance, legislative regulation, and numerous other subjects of political science. The development of the railroads necessitated labor. Here could be made an examination of the unionization of the workers. These are only a limited number of illustrations of the method of introducing students to the fundamental principles of economics. The obvious gain here is that the principles become less theoretical and more practical in their application. They are likely to acquire more value and to be retained longer in being applied.

During the junior and senior years, the course takes a slightly different turn. It is in the main a continuing of the social studies in the way previously explained, but it puts more emphasis on the individual student.

Groups of students are permitted and encouraged in the junior year to concentrate attention upon selected historical and current topics. As far as practicable, students are given the option of choosing subjects for special study from alternative groups of topics. Irrespective of the phase of social relations with which a particular group is occupied, the work of the junior year is directed toward mastery of scientific methods, discriminating judgments concerning social situations, and an enlarged understanding of society, especially in its dynamic aspects.

The senior year continues this theme and this practice, providing more opportunity for the students of unusual ability.

Each student is expected to make an independent study of some significant phase of social relations and to embody in a final report of his findings, evidence of competence in respect to the several objectives pursued during his four years of study.

For the large number of senior students the program will be group or class study of social topics of special interest.

This is the course as it has been mapped out. The teaching personnel has been recruited largely from the academic studies staff. Instructors who previously taught only economics, or history, or English, or the like, will now conduct classes in social relations. It is thought, and quite justifiably, that the breadth of training of these teachers together with some study and reading devoted to the social studies in the current scene will be sufficient for the instructional purposes of the course.

During the past year a seminar program in social relations with a group of able seniors was tried and with unusually good results. They had had only the traditional courses in economics, history, literature, and the like. Under the guidance of an adviser each student worked out a project of non-technical nature. Such topics as social security, labor unionization, city housing, propaganda in schools, and the like were studied. It was the general feeling among the advisers that the work of the students would have been better if they had had the social relations program as now planned.

Thus we have provided for one group of what might be paradoxically called "basic" service courses. Let us examine another. It will be remembered that the fifth objective of the social relations program is "ability to use the English language to express . . . thoughts effectively, both orally and in writing." This statement means that throughout the four years there will be an insistance on competent expression. The members of the English Department will be on call for assistance in bettering the expression of the students. Instructors themselves have been conditioned to make the students aware of the value of competency in the use of their native tongue. It is now planned to penalize slovenly and careless expression.

The statement of this objective does not mean the elimination of the freshman course in English. This is still regarded as a foundation course in chemical engineering training. It may be described as a service course, but a basic one. The time may come when the high schools will do a sufficiently competent piece of work for colleges to dispense with the freshman course in English, but it has not yet come. In fact the latest statistics indicate that a negligible percentage of colleges and universities exempt entering students. Some attention should be given to this matter, for unquestionably there are some who should not be required to do freshman English in whole or in part. At the Carnegie Institute of Technology we have a selective program. We make our selection on the basis of a grammar and mechanics test, impromptu and prepared writing, aptitude tests, and the entrance record. The

definitely competent students should be exempt from any requirement in freshman English.

The conventional freshman English course for chemical engineering students, required of the large majority of students, should also have its objectives. First of all it should be a college course and not a high school course. Such matters as the elements of the language should be presupposed. This observation may be regarded by many as too much to ask at present. However, there has been some tendency to regard the weaknesses in the elements of English too closely. The result has been the direction of too much instructional energy to the correction of faults with a possible result of the teaching of faults. It is not freedom from faults but the presence of powers that makes the expressive piece of composition. Hence it is that the emphasis should be put on the positive side—the development of these powers—rather than on the negative side. We have all seen good clean writing that meant very little.

In the second place, the course in freshman English should have a three-fold purpose. It should develop the student's skill in technical writing. He will need to know how to write expositions of processes and mechanisms and definitions, to compose letters and reports. He should begin this in his freshman English. He will also need to be able to write evaluations of ideas, such as he will meet in his social studies, literature, and the arts. Further, he will have need of English as an outlet for his individuality, his pent up feelings and emotions, his criticisms and his protests. In some instances it will be advisable to encourage students interested in composition of literary quality. These objectives seem comprehensive enough, and no one of them should be neglected if freshman English is to be a serviceable course for the student of chemical engineering and the social sciences who is to be developed into an educated man.

While this training is in process, it should not be too much to expect of the course that it stress oral as well as written composition. The basic elements of good oral English might be introduced. And certainly the student could be taught how to make a good recitation.

After the student completes his freshman English course, he is inclined to let down. In the free atmosphere of the laboratory he will become careless. With his instructors in technical subjects he may have the impression that substance rather than form counts. We have made a start to correct this practice by setting up the principle that the student is required to use respectable English throughout his four years of college. The Department of Chemical Engineering has put teeth in this provision by penalizing badly

written papers and examinations. This penalizing is done by the Department itself, not by the Department of English. To a remedial committee of the Departments of English and Psychology are referred deficient students who were able to squeeze through freshman English, for the purpose of further instruction.

In the senior year we have inaugurated coöperative work in the engineering seminars between the English Department and the technical department. This experiment has worked out very well. It is conducted in conjunction with the work of the students in doing their undergraduate thesis. During the first part of the course, the student is given instruction in the elements of public speaking and report and letter writing. He is then asked to present oral expositions of summaries of selected articles from the technical literature of his major study, blackboard and lantern talks in which he uses diagrams and graphs, demonstrations of instruments used in testing, explanations of fundamental scientific principles. These are presented to the class in the presence of his technical adviser and his English adviser. In some instances they have been rehearsed. The student is criticized both for content and for form. And the criticism is given immediately following the presentation in such a way as to permit him to defend himself or to emphasize a merit or to correct a fault. Sometime during this period the student has selected his thesis problem that he wishes to investigate in the laboratory. He is taken to the library to become acquainted with its facilities. After some study of the problem, especially through its literature, he is required to write a preliminary report explaining the significance of the problem, its background as evidenced in the technical literature, its definition, the apparatus that he expects to use in experimenting, and the method by which he intends to solve it. This report is carefully checked by his technical and his English advisers. Further, he presents his report before them in an oral rehearsal, and then he presents it to the class. In the course of events he prepares a progress report for his advisers, stating to what stage his work has progressed, what difficulties he has met, and what his prospects are. This report is also checked by both of his advisers. When he has completed his work, he presents a final report. This also is written, rehearsed, presented, and criticized as the preliminary report was. The results, as has been observed, are very satisfactory. It is not an exhaustive course in letter and report writing, but a very effective practical one. In the exposition of the elements of these forms of composition, the instructor takes cognizance of industrial practices and requirements. This material is not presented during any one period in the year, but is distributed. There is ample opportunity for this instruction, and

it can be fitted into periods when the students are at work in the laboratory and not prepared to make any class reports. Furthermore, this discipline is closely associated with work in which the student is tremendously interested, and at a time when its value looms large. It is a service course that renders service.

A somewhat similar coöperative plan is in operation in the senior social relations course. It is apparent, therefore, that the student is conscious of English for four years with special emphasis on the first and fourth years.

It seems to us that within the time limits the basic science and engineering courses plus the social relations program plus the training in English round out the broad general and special training of the student preparing for the profession of chemical engineering. This integrated training makes engineering a culture as well as a career.

Let us next consider what is to be done with service courses that are not so basic as the humanities and English, such courses as accounting, typewriting, shops, contracts and specifications, commercial law, foreign languages, and the like. There is no place for them in the curriculum. This exclusion does not mean that such courses are not desirable, that they would not be serviceable to a prospective chemical engineer, that the occasion will not arise when a knowledge of their content would not be exceedingly opportune. It does mean that there is not enough time in a four-year undergraduate course for their inclusion, that these invaluable four years can be utilized to greater advantage in basic course discipline, that these courses tend, in that they require additional preparation, to divert student attention from essentials, and that if this type of training is needed and desirable—and it very often is—it can be gained more profitably and more economically before entering college, during parts of the vacation periods, or after graduation, than it can be during the regular college term. Vocational, evening, and correspondence schools have all the facilities for giving these courses in due time and probably at a tuition cost that is lower than that of an accredited engineering college.

It goes without proving that these courses with their limited objectives are not of the same quality as the basic courses that have been mentioned. They cannot be because of the lack of time to do them well. They are incidental. They do not test the apt student's ability. Too often they are used as a saviour for the inapt student. Furthermore, they often endanger the scholarship record of a student who is required to take them, but who finds himself uninterested in them.

As a rule these courses are inclusions or superimpositions on the desirable standard curriculum. Too often they are the result of

the demand of an industry which has the limited view of what a college should produce, to wit: a trained instrument or machine capable of immediate production rather than a well-rounded educated man capable of making a contribution to his profession, his society, and himself that is worthy of his intelligence and education. Such industries should take further inventory of their personnel. It is likely that they will find that they need the educated man rather than the trained instrument and that it is highly possible for them to place at the service of the educated man available and able personnel in accounting, law, shops, drawing, and stenography.

It will be strange if some one does not question the lack of emphasis on foreign languages in the curriculum. It will be urged that much valuable scientific literature is appearing in foreign publications. This is true: in German, French, Italian, Dutch, Swedish, Russian, and Japanese publications. It is obvious that a reading knowledge of all these languages is too much to ask. The result is a compromise—a reading knowledge of German or French or both. This seems not unreasonable to require. It likewise seems reasonable that the engineering department should be the judge of the student's attainment rather than a foreign language department, especially one not too sympathetic with such requirement or perhaps not adequately acquainted with the student's departmental needs. A possible solution for this problem would be to make the reading knowledge a non-credit requirement for graduation, like swimming. The student in his vacation time could take such steps as are needed to meet it.

Furthermore, some will urge the need for shop training. Here again are variety and compromise—machine, pattern, wood, welding, brick-laying, foundry, forge, pipe-fitting, sheet-metal; and which ones shall be specified? Any one of them will develop manual dexterity. This statement does not mean that that is all that shop training can develop if enough time and emphasis are given to it in an undergraduate curriculum. It does mean that sharply curtailed shop training develops little more than manual dexterity. For the problem of getting any shop training there are several answers. First, some students enter college with some shop training gained in either junior or senior high school. Second, some students have part-time summer employment in which they can gain shop experience. Third, it will be possible for departmental instructors to advise students in the progress of laboratory courses needing the construction of routine or special apparatus, concerning shop practices and applications in the ways of preparing this apparatus. And as a last solution, the student may take some shop work during the vacation period.

One further point needs to be disposed of in connection with these "service" courses. It may be urged that they might be included in the program of exceptionally able students, or students who have been exempt from some curriculum requirement, such as the first course in mathematics or English. This practice is objectionable. Time limitations were not the only reason for not including them. The student can spend his regular educational time to much better advantage developing himself in the basic courses. It would seem to be an unhappy state of affairs if these more capable students should be advised to devote their spare time and energy to the development of manual or memory skills in shop and language courses that have been reduced to the barest essentials. It would be far better to allow them freedom to exercise their own initiative.

In all of these matters the student should be well advised. The department should have a complete record of the student. Departmental advisers should know the individual students. If the student has a clearly defined objective, the adviser should inform himself concerning what it is and the ways leading to it. If it will require graduate work, the student should be pointed for such work as early as possible. If the student has as his goal the editing of a scientific publication, it is obvious that his previous attainments and his goal must be studied in order that his present training may be determined. In these analyses the adviser can dispose of these problems of "service" courses. If, for example, the student needs the reading knowledge of some of the foreign languages, he can be forewarned and hence prepared to meet his need.

On the other hand, it will be even easier to advise a student with no definite goal beyond the study of chemical engineering. The conventional opportunities here are pretty clearly defined. The student's inclinations and aptitudes can be studied to determine his general fitness to take advantage of any of the available employment openings, and his general curriculum can be modified or added to in accordance with his needs.

In the curriculum of the Department of Chemical Engineering at the Carnegie Institute of Technology, Doctor McCabe and his associates have included a course entitled Professional Development. In it are discussed the important general points in the profession, such as the opportunities, the needs, the demands on the students. It especially stresses the development of the student personality. In the textual matter of the course there is included an excellent pamphlet, "Technique of Good Manners—A Handbook for College Men," by Mary Perin Barker. It is a text that is worthy of recommendation to all educators for use with

their students. The title suggests its content and indicates in part the kind of work Doctor McCabe and his associates are doing in the course in Professional Development. Further, this course serves as the development point for advisory work.

One other matter deserves special mention. It is the three-two plan which the Carnegie Institute of Technology has arranged with certain approved liberal arts colleges. It makes possible a three-year liberal arts course which includes training in the basic sciences and in English at the approved colleges and an engineering training on our campus. At the conclusion of the five-year program, the students are awarded a bachelor of arts and a bachelor of science degree. We expect good results from the plan. In its way it adopts the suggestion of some engineering educators that the training in engineering should be preceded by a liberal arts course—a requirement now in force in reputable colleges and universities for training in such professions as law and medicine.

In conclusion may we say that the program which we have laid before you for including service courses in the undergraduate chemical engineering curriculum has its objections and flaws. But it is realistic in the face of all the limitations placed upon it; it meets every basic need; it does make the best and most economic use of the student's undergraduate time; it prepares him for the chemical engineering profession, for his place in society, and for the satisfaction of those personal needs and desires to which he is rightfully entitled; and in the last analysis, it serves to inspire him, while he is in college and throughout his entire life, to continue his progress toward the goal of becoming an educated man.

TEACHER QUALIFICATIONS AND DEVELOPMENT*

By ALBERT B. NEWMAN, College of the City of New York

Professor and Head, Dept. of Chemical Engineering

Introduction

It seems to me particularly appropriate that the title "Teacher Qualifications and Development" should occupy a prominent place on your program. In explaining this statement, I can do no better than to use the words of W. K. Lewis when he spoke on the same subject thirteen years ago: "Mr. Chairman, I think the qualifications of teachers of chemical engineering is, bar none, the most important subject we have under discussion today. I would al-

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most go so far as to say it is the only important subject, and I will tell you why: education is not a matter of organization. Education is a matter of contact of personalities. That is all it is." To those of you who have not read recently this address of Dr. Lewis, I recommend that you do so. You will find it in the 1926 volume of the Transactions of the American Institute of Chemical Engineers.

In developing this subject, I feel that I cannot do so in the inspirational manner of Dr. Lewis, but I do feel that the situation in chemical engineering today calls for a more detailed analysis than was possible or desirable in 1926. Whether we like it or not, state licensing boards, admissions committees of professional societies, accrediting agencies, even the boards of trustees of schools, are expecting tangible qualifications as to personnel, and are insisting that these qualifications shall be of the kind that can be put down on paper and evaluated.

Any thorough discussion of teacher qualifications and development must include an analysis of the environment in which he works, and I am therefore taking the liberty of extending these remarks to include departmental organization and its relation to the general organization of the school and its engineering division.

Teacher Selection

In making a detailed analysis of the desired qualifications for the various instructional grades, it must be kept in mind that allowances must be made for size of institution and its department of chemical engineering. In the following remarks, I have in mind a school of average size, although some of the remarks apply particularly to the larger schools.

(*a*) *Selection of Department Heads and Others of Full Professional Rank*

This selection may be made by promotion from within the existing staff, from another school, or from industry. It is obvious that the man selected must be intensely interested in the intellectual development of young men.

If the selection is made from within the staff or from another school, the question should be raised whether the man has worked for so long under a professor of dominating personality that the candidate has lost whatever qualities of leadership he might have otherwise developed. If the man possesses the qualities of personality, leadership and interest in young men, his technical qualifications should be examined, and the best selection will usually be a man with a record of achievement as a scholar plus a suc-

cessful period, culminating in responsible charge, in industry. In general, it may be said that the man should be able to match the requirements for active membership in the American Institute of Chemical Engineers and in addition should have shown continued development on the intellectual side of chemical engineering, so that he will command the respect of the more intellectual members of the staff and student body.

If the man is to be selected from industry, the task of selection is difficult, and a final decision should be reached only after careful investigation and consultation with many people who are qualified to judge, including members of the departmental staffs, a procedure which is usually followed. The man in industry being considered should have the same qualities of personality, leadership and interest in the development of young men as any other candidate. The danger is that he may have become so absorbed in the details of some particular industry that he has forgotten, if indeed he ever knew, how to make a theoretical analysis of a problem. He may have become more or less successful in so-called "common sense engineering" or "horse sense engineering," may have become expert in certain techniques of the specialized industry with which he has been connected, and look with disdain on theory as "high-brow stuff" having little or nothing to do with engineering as he sees it. He may visualize himself as teaching the minute details of the industry in which he is expert, not realizing that present-day teaching of chemical engineering attempts to teach principles and their application and the teaching of the details of industrial processes has become of minor importance.

The industrial man may also think that he should transplant to the school the industrial point of view of "boss and employe" in his relations to other members of the staff. We all know that the successful department head seldom finds it necessary to exert authority over staff members and seldom has to advertise the fact that he has such authority; he knows that he must win support for his proposals by sound argument and tactful persuasion. The department head who says that he is going to get his way because he is boss and never lets the staff forget for a moment that he is boss is doomed to ultimate defeat or to the headship of a lifeless low-grade department.

Presumably the full professor or department head recruited from industry at this time should possess his doctorate. We can all think of three or four notable exceptions: men without doctorates who are now in industry but whose published work is on the post-doctorate level; these men would be welcomed into the top notch teaching jobs. The point is that the full professor

should be in the habit of doing his thinking on a high intellectual level if he is to command respect from staff and students. It seems obvious that the full professor and department head should be able to teach successfully the advanced courses given by the department. In general it may be stated that the safest group in industry from which to select full professors consists in the men, mostly between 35 and 40 years old, who were among the first to receive their doctorates in chemical engineering. Men over 40 with doctorates in chemical engineering are comparatively rare, as are those without doctorates under 40 who are qualified for top teaching jobs. In spite of the natural preference for older men for these top jobs, it seems safer to choose fully qualified men under 40 rather than take chances on older men who have not worked continuously on a high intellectual level. In a few years there will be a better available supply of the over-40 qualified group.

If it is a case of a man in industry seeking a teaching job, his motives should be analyzed and appraised, because this appraisal will give a definite clue to his actions after appointment. I give you below some of the motives I have heard expressed, and I leave the analysis and appraisal to you:

(*a*) Candidate has not advanced rapidly in industry, and he believes that he can improve his economic situation and general status more rapidly in teaching.

(*b*) Candidate is keenly interested in the development of young men and in modern chemical engineering.

(*c*) Candidate believes that schools should be as highly organized in administration as are industrial concerns and that his industrial experience will enable him to introduce business methods into the operation of the chemical engineering department; his primary interest is in administration, and he believes that he has special qualifications for administration and that the essential needs of a department are organization charts, periodic reports from the staff, printed forms, and cleared desks at 5 o'clock every afternoon. He will need the services of an interior decorator to make sure that his office furnishings will make him look like a high executive of a large corporation.

(*d*) Candidate believes that success in teaching is much easier than success in industry. A teaching load of six hours per week with two or three months' vacation in the summer looks appetizing. To this candidate, a teaching career looks like retirement after an active period in industry. He is also attracted by the economic security offered in teaching as contrasted to the lack of such security in industry.

(*e*) Candidate is of the intellectual type, a thinker along theoretical lines, and, having had little or no opportunity to develop along these lines in the particular industries with which he has been connected, he believes that an academic connection will give him broader scope to satisfy his desire to contribute to the development of chemical engineering theory.

(*f*) Candidate is applying for a teaching job which carries a higher salary than he has been able to command in industry.

(*g*) Candidate is in an industrial position which requires him to make frequent trips on short notice. His wife wants him to get a job which will not require him to travel. Candidate is indifferent as to whether he would rather be in teaching or industry, as long as he receives enough compensation to support his family, and perhaps would lean toward industry if it were not for the traveling complication and the consequent pressure exerted by his wife.

You will note that I have not mentioned administrative capacity as a qualification for the full professorship. I believe it true that a man possessing the other qualifications will be willing and able successfully to handle the relatively small amount of administrative work to which a department head should give his time and which cannot be done by an efficient departmental secretary. That administrative capacity is no criterion for selection of a professor in an institution of higher education is emphasized in a recent Harvard University report [1] which states:

> Administration presents a special difficulty. On the one hand, there is administrative work to be done, and to be well done it often requires the experience and the standing of the scholar and teacher. On the other hand, it is evident that administrative capacity affords no basis for judgment in the selection of men for careers in which scholarship and teaching are the essential requirements. Administration lies outside of the strictly professional career of the members of a faculty, as it lies outside of that of the physician or artist.

I have mentioned intellectual level, and again quote from the Harvard University Report: [1]

> (*c*) Intellectual emphasis. The age in which the teacher taught out of a text-book, or duplicated the written with the spoken word, is happily past. Students are quick to disparage the class-room teacher who merely gives them what they can easily get for themselves. Good teaching still requires a skill in the imparting of knowledge. The growing tendency

[1] Report on Some Problems of Personnel in the Faculty of Arts and Sciences—by a Special Committee Appointed by the President of Harvard University—Harvard University Press, Cambridge, Mass.

to use sources in place of secondary texts enhances the importance of this task. To make a synthesis of existing knowledge suited to the students' stage of advancement, and conveyed in a form and manner suited to the students' rate of assimilation is a high if not a rare art. The best teacher will know how to employ this art to supplement rather than to supersede the efforts of the students themselves.

(*b*) *Selection of Associate and Assistant Professors*

The potential supply of qualified men for these grades is much larger than that for the full professorship. The age may vary from the late twenties up toward the forties, according to the size of the school and the salary scale existing. If a man is to be selected from industry, it is obvious that one would look for the doctorate plus success in industry plus the personal qualities outlined for full professors. For a man who has already spent some years in successful teaching, the qualifications for active membership in A. I. Ch. E. afford convenient criteria for promotion. If the man now in teaching meets or is headed toward meeting these requirements, and has the qualifications mentioned above, an intelligent selection seems assured.

(*c*) *Selection of Instructors and Teaching Assistants*

In most schools, these are temporary grades. The man selected may be headed for a career in teaching or industry. He will be teaching the more elementary standardized courses, and he will not be expected to meet the full qualifications of a man for professorial rank. In many cases he will be working for an advanced degree in the same institution or a neighboring one. It is particularly difficult for a young man just graduated to start teaching in the lowest grade and work up by promotion to the upper grades, without a few successful years in industry at some stage of his career. The young man who visualizes a teaching career without industrial experience should realize that he is classifying himself as a professional educator and not as a chemical engineer. It is true that a man can sometimes qualify for the top jobs without breaking his connection with academic work. If he is capable enough, he may make a name for himself by publishing the results of high-grade fundamental research or by equally high-grade consulting work for industry. The point is that a man cannot qualify for the top teaching positions by teaching only.

Development

Development has been touched upon in the discussion of qualifications, and I can add only a few points. I would be presuming

too far if I attempted to say what a full professor or department head should be doing to develop himself. He may choose to carry a light teaching load to give himself time to build up the reputation of his school by outside efforts which may include maintaining contact with industries, committee work for professional organizations, or other legitimate activities. During certain periods of the year, much of his time will be well spent in the placement of graduating students. In order to do this intelligently, he should have a thorough knowledge of the personalities and abilities of his students obtained by periodic interviews during the three or four years the students are in the department and by discussion of individuals with other members of the staff.

Associate and assistant professors will usually have their plans for further development already made. They should be given the utmost freedom in the selection of a field of research, consulting work, text-book writing, professional society activities, etc., and there should be no hampering supervision over these activities. However, if one of these men goes through an unproductive period, he should be told that this fact is being observed and he should be tactfully urged to get busy on something constructive.

Instructors and teaching assistants will ordinarily require more guidance in planning their working time, and the senior staff members should not begrudge the time they spend in conferring with the junior members on questions of professional development. The important thing is that these junior members should not be so burdened with teaching hours and routine administrative duties that they cannot find time and energy for their professional development, whether it be research or other scholarly production, consulting work, or other developing activity.

Criteria for Promotions in Rank and Selective Salary Increases

In many schools, salary advances within a grade are automatic up to a certain limit, and after that limit has been reached, the advances become selective. In nearly all schools, the promotion to higher rank is selective. Several of the criteria applying particularly to chemical engineering have already been enumerated. An excellent set of general criteria, applicable to all engineering teachers, has been published by the Massachusetts Institute of Technology: [2]

1. The professional activity of every full-time staff member should be dedicated primarily to the service of the institution, and to the public welfare.

[2] Policies and Procedures—A Statement for the Information and Aid of Staff Members—Massachusetts Institute of Technology—January, 1939.

2. Every full-time member of the Staff should devote full-time effort to the activities described below:

(1) Teaching the students of the Institute, in formal classes and laboratories, and in informal groups and conferences.
(2) Preparation for such teaching.
(3) Study for the purpose of keeping abreast of the profession, and for improving teaching skill.
(4) Administrative and committee work in the Institute, and professional service to the Institute on its internal problems.
(5) The writing of professional papers and other serious contributions.
(6) The writing of texts which are written principally for their value to the profession or to teaching technique.
(7) Activities in professional societies, of such nature as to advance the profession.
(8) Consultation with colleagues for the purpose of advising them in their problems, especially counsel to younger staff members.
(9) Services to sister educational institutions, to governmental bodies, and to institutions privately maintained for the public benefit.
(10) Representation of the Institute before the public in lectures and in similar ways.
(11) Supplying counsel and guidance to students in worthwhile extra-curricular activities.
(12) Research of all forms carried on to advance knowledge, or improve the art, and thus of immediate or ultimate public benefit.
(13) Consulting service to and research for industry, of such importance and dignified nature that its carrying on enhances the prestige of the Institution, vitalizes teaching, and provides helpful contacts for the student.

3. It is assumed that every individual should engage in certain activities or pursuits which are essentially recreational, although they should not, of course, be indulged in to such an extent that they interfere with the proper discharge of the individual's primary responsibilities to his institution.

4. It is the duty of each staff member to keep his department head informed regarding the general scope of his professional activities, particularly with respect to any major commitment involving a substantial portion of time or extended absence, and to be guided by the counsel of the department head or of the administration in ordering his activities, so that his services may be of genuine value to the institution and properly coördinated with the activities of his colleagues.

5. The decisions of the administration on all salary adjustments should be based on the principle that salaries paid to staff members shall be in proportion to the value to the institute of their total contributions; and it should be recognized that this total is affected, not only by the extent and nature of the activities, but also by the effectiveness with which they are pursued.

Organization of the Department

From the standpoint of effective operation of the department, I think you will agree that the minimum amount of organization is the best. The amount of money to be spent annually, exclusive of salaries, does not justify a complex business organization. Occasionally one hears a professional educational administrator remark that what is needed in departments is more emphasis on administration. In some cases administration weighs so heavily on department head and staff that the fundamental aspect of education, the teaching of students, is almost forgotten. Such emphasis on administration will soon sterilize any department of chemical engineering, as it is inevitable that this emphasis will lead to standardization of routines in teaching and research; the instructor soon loses his individuality and conforms to the system. The junior staff members should not be distracted from teaching and scholarly pursuits by having to do clerical and semi-administrative work. The senior staff members are being too well paid for them to spend their time on detailed administrative work which can be handled by an efficient secretary. The departmental secretary, whether it be woman or man, should be a responsible person at least on a basis of equality with the junior staff members, should be on permanent appointment after a probationary period, and should possess considerable authority in routine administration. In a department of moderate size, there should also be a stenographer, reporting preferably to the secretary, but available for service in departmental work and for the individual members of the staff for their professional work. Obviously, this provision of secretary plus stenographer is the most economical arrangement for getting the work done. Every department of chemical engineering should have available the full-time services of a mechanic. His duties will be the construction of equipment, assembling of experimental set-ups, guiding students in those same activities during laboratory sessions, care and repair of measuring instruments, and general attention to all of the mechanical equipment of the department not under the supervision of the superintendent of buildings.

The question of relative authority of department head and staff on matters of policy, of new appointments and promotions, etc., is a delicate one, and there are to be found today institutions in which the department head is an absolute dictator and, on the other hand, institutions in which statutory provisions require every matter to be settled by majority vote of the staff after the chairman has been selected by the same method. It is too early to predict the success of the latter scheme, but it seems likely that

the adoption of such a scheme could work out with marked success only in large, well-developed and stabilized departments with many years of achievement behind them. In keeping with the times, it is certain that something much less than dictatorship should be sought. Regimentation of scholars should be curbed. On the other hand, there should be some experienced guidance, and it is possible safely to vest considerable authority in a chairman, provided you have a man of the best type as chairman and there are open channels of appeal from arbitrary decisions he may make.

Administrative Relations in General

Experience has shown that chemical engineering thrives best when set up as a separate department, independent of chemistry. Many arguments can be developed showing that sooner or later, trouble arises when the chemical engineering staff forms a minority group in a department of chemistry, but such arguments are outside of the scope of this paper.

If a Dean of Engineering has general supervision over chemical engineering, he may usually be expected to be sympathetic toward chemical engineering. To guard against a possible unfriendly attitude on his part toward chemical engineering, there should be an open channel of appeal from his decisions, with the understanding that such an appeal will be welcomed and considered on its merits without precipitating an administrative crisis or strained personal relations.

This matter of open channels of appeal is one which I have not heard openly discussed. One president of a board of trustees has stated to me that the board hires a man to run the school just as the board of a business institution employs a general manager to run the business, and they give him a free hand as long as he runs it successfully, entertaining no appeals from subordinates. But I raised the question: "What is the measure of his success in running the school?" When I received a vague answer to this question, I pointed out that the results of the operation of the engineering department of a school are intangible as compared with the operation of a business institution or one of its departments, in which you have a periodic financial report as a very tangible measure of the success of the responsible individual. If an administrator knows that there are regularly set up channels of appeal, I believe that occasions upon which such channels might be used would become more rare than at present; certain administrators would avoid making obviously unfair decisions affecting departments and individuals.

Conclusion

The popular conception of the life of a teacher is easily understood. Because a professor has a teaching load of only six hours a week and has a summer vacation of two months or more, people are likely to think that he is living a life of ease. We all know that nothing could be farther from the truth in most cases. The professor cannot possibly do his work within the hours of 9 to 5, which has come to be a sacred symbol in American life. If the professor is to be successful, he must burn much midnight oil. There is a nervous strain associated with intense teaching, and most teachers are on the ragged edge when June rolls around. A period of recuperation is a real need. If a teacher starts his work in September when not in the best physical condition, there is real danger that he will break down before the following June.

In spite of the thorny path toward the top and in spite of the hard work we do, we have a strong affection for chemical engineering and its teaching; otherwise we would not be here today.

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CIVIL ENGINEERING PAGE

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THE DEMONSTRATIONAL LECTURE METHOD OF TEACHING HYDRAULICS*

BY LORENZ G. STRAUB, Director of the St. Anthony Falls Hydraulic Laboratory, University of Minnesota

An analytic approach to definition of the laws governing a physical occurrence necessarily presupposes a clear conception of the nature of the phenomena. Here the age-old proverb "Experience is the best teacher" certainly is applicable to the acquisition of knowledge regarding the various motion cycles which take place under the influence of natural forces. The curricula of our leading technical schools give evidence that this proverb has tacitly been accepted as axiomatic; on the other hand the question continually arises as to how much use the beginner can make of the accumulated experience of others without some personal contact of his own with the physical occurrences involved.

The laboratory has become established in the college as an indispensable aid to the teaching of physical sciences. Simple occurrences are brought about in the laboratory by the student's own effort and direct observations are made by him for the purpose of supplementing and confirming in part statements made in his textbook, in the classroom, and in the lecture. These scattered personal experiences with physical phenomena, although they are quite fragmentary, provide a framework on which the student can build a more completely fabricated structure by closing the gaps with a knowledge of the observation and personal experience of others and by analytical deduction. The broad field of information must be obtained from the textbook, the classroom and the lecture. It cannot but be conceded that the skeleton of this complex structure of knowledge remains largely the sum total of the learner's personal experience.

More recently the laboratory procedure has been closely scrutinized by many college faculties because it is recognized to be a time-consuming method and its relative efficiency has been questioned. Doubtless, in many instances the principle of the laboratory approach has not been subject to question, but rather the character of the problems which the student has been required to solve by experiment. The framework of experience around which the student builds the knowledge obtained from books and lectures must adhere to fundamental principles if it is to be of any consequence. Experiments on occurrences which are obvious to the student at the outset are time-consuming and of no benefit. To be sure, this matter is relative, and therefore, subject

* Presented at the annual meeting of the Civil Engineering Division of S. P. E. E., Pennsylvania State College, June 19, 1939.

to some dispute because of the differences in individual mentalities and capacity for analytical deduction.

In order to reduce the time spent in individual experimental work there has been a trend toward a demonstrational lecture procedure by means of which the student is given an opportunity to observe natural occurrences without going through the more complex and time-consuming procedure of producing these phenomena himself. Admittedly his experience of detached observation cannot be expected to crystallize for him as clear a conception of the occurrence as when he is definitely involved in producing it. The demonstrational lecture thus cannot be expected to replace the laboratory. It must be regarded as a supplement to the laboratory and classroom, a means of bringing more efficiently and effectively to the student's attention fundamental conceptions. It is a means of providing the dramatization of fundamental physical laws.

In general physics the demonstrational lecture has become an accepted fact at all leading educational institutions. The demonstration of the properties of liquid air, for example, provides a dramatization which no student will soon forget. The mere reflection on observations of this character crystallizes fundamental knowledge in the student's mind in a way which would not be otherwise possible.

The modern physics auditorium has become a room in which demonstrational equipment can be readily set up and dismantled in accordance with needs. Some inherent difficulties are involved in the attempt to provide a similar arrangement for hydraulics. In consequence, although the method of teaching by demonstrational lecture has been recognized, the equipment has tended to become a fixed character, not readily changed to meet the progressive changes throughout a course and the developments from year to year. Consequently, the demonstrational hydraulics lecture has sometimes been carried out in the laboratory where only a few students could be handled at one time, whereas when established in an auditorium interest has lagged because of the immovable nature of the equipment.

In recent years the hydraulic laboratory has undergone many changes and innovations with the thought that progress can be most readily made by providing the greatest possible flexibility. A maximum of space is required and a minimum of built-in, immovable equipment. To be sure, certain fixed installations are necessary, but these can be confined to supply reservoirs and similar installations. Even the pumping equipment is now advantageously arranged to be moved from point to point as required for specific research problems.

For an effective demonstration lecture room for hydraulics the modern thought of hydraulic laboratory development can be adopted advantageously. There should be no more fixed equipment than is absolutely necessary and this equipment should preferably be out of view of the students in order to avoid distractions from the subject matter of the day. Preferably it should be possible to dismantle demonstrational apparatus on short notice and replace it with other equipment. It is possible to provide demonstrational lectures effectively in the auditorium to large groups of students. Blackboard space provides a means of analytical treatment of the occurrences. The more complex situations which cannot be completely demonstrated by simple experiments might be supplemented by the use of moving pictures. In any case, however, the flexibility of change is without doubt of primary importance as a safeguard against an antiquated procedure.

(Memorandum. Supplementing and following this talk there was presented a moving picture film illustrating in part the demonstrational hydraulic lecture procedure being developed at the University of Minnesota in an especially arranged hydraulic auditorium. The students in elementary hydraulics

meet there once a week, all sections being combined for a common lecture period. Up to about two hundred students may be handled comfortably at one time. The lectures in general relate to the subject matter being studied in the classroom and the laboratory. The demonstrational experiments are explained with supplementary sketches on the blackboard and sometimes by moving pictures.

The lecture room forms a part of the new St. Anthony Falls Hydraulic Laboratory of the University. It is so arranged that large quantities of water can be handled readily at the lecture platform in various types of demonstration experiments. Below the lecture platform runs the main overhead supply flume for the laboratory on low levels, while above the lecture platform is a head control run, containing a constant level reservoir, situated in a tower above the auditorium. In a large room adjoining the auditorium space is provided for housing the demonstrational equipment. This allows for complete removal of apparatus from the lecture room or of the interchange of equipment as may be required for lectures in different fields of hydraulics.)

NOTICE

The *Civil Engineering Bulletin* will be distributed to teachers of civil engineering in December. Teachers having made a change of institutions this fall should report their new addresses to the editor, together with their old address.

ENGINEERING ECONOMY PAGE

Every graduate of every engineering school should be familiar with the question, "will it pay?" have a firm grasp of the arithmetic of engineering economy, and a consciousness of costs which will make him ever mindful that an engineer is a man who can do for one dollar what any bungler can do for two.

EDMUND D. AYRES, University of Wisconsin, *Editor*

WHY TEACH ENGINEERING ECONOMY?

The most urgent problem in connection with Engineering Economy in my opinion, is not what the term shall mean, but the necessity of having such a course included in every curriculum. If this page in the JOURNAL can reach some who have not thought about this particular subject, and can influence them to investigate how a study of the question, "Will it pay?" can broaden and deepen the training now being given, the return to the profession will be great.

An engineer has been defined as a person who can do for one dollar what any bungler can do for two. Notwithstanding that this definition "tickles the vanity" of most engineers, many men are being graduated from our engineering schools without any consciousness of how costs affect every aspect of their work. The civil engineers who have gone out during this late depression have some realization that the lack of new construction has kept them from having a job, but they have as little knowledge of why such a condition exists as has a laborer or artisan. It seems to the writer that the engineering schools are under a deep obligation to introduce all engineerng students to the problems of economics and to supplement such courses with a thorough training in solving the question, "Will it pay?" Those of you who have read the writings of Daniel W. Mead will remember his definition of the most important question of any job. It is the one that was forgotten. No one recognizes more clearly than the writer the impossibility of solving, in college, questions of the nature of "Will it pay?" that will arise when the graduate meets them in his practice, but we should make him cost conscious, so that such questions will not come in the classification of Mead's "most important."

Thirty years ago in structures men were taught that 95 per cent of all steel trusses were Pratt trusses, because they were cheaper. The only cost in the whole bridge of which they were conscious was the steel in the trusses. Even today if the instructor has the inclination to answer that question more completely, it is doubtful economy to have him do it, because there is the necessity to teach undergraduates more theory of structures than was taught in graduate schools thirty years ago, and the time required to insure a knowledge of the arithmetic of economic comparisons is considerable. If every instructor deducts that time from each design course, it is wasteful indeed.

The reason for introducing Engineering Economy into the curriculum is to make the students of engineering cost conscious. Throughout their work in

engineering, the emphasis has been placed upon the best designs and the best construction, regardless of cost or local conditions. This approach is, in general, unavoidable. Before leaving college, it is essential that they realize the cost of money, the time value of money. It is impossible to illustrate every situation in which these questions will arise, and therefore it behooves the schools to insure a knowledge of compound interest, and the methods of referring expenditures to one time. If this has been thoroughly done, and the student inoculated with the cost virus, he will of his own volition seek out and master the list of subjects suggested by our editor on page 234 of the November, 1937, issue of the JOURNAL OF ENGINEERING EDUCATION. The masthead suggested by this line of thought is given at the head of this page.

SCOTT B. LILLY,
Swarthmore College.

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*, University of Virginia

V

TEACHERS OF ENGLISH IN ENGINEERING COLLEGES: SELECTION AND TRAINING*

By H. L. CREEK

Head, Department of English, Purdue University

The Complaints

Although some persons believe that the training in English for engineering students is successful, at many institutions there is enough dissatisfaction with the teachers of English to disturb complacency. This dissatisfaction is expressed both by educators and by engineering graduates, who suggest new criteria for selecting such teachers and modifications in their training. Their indictment and their suggestions will be studied in this chapter in an attempt to draw conclusions that may lead to action and improvement.

"The teachers who are giving this work are typical English teachers, . . . more imbued with literature, dramatics and English composition than with the phases of the work the engineer especially desires to obtain." This complaint of the dean in a Western land-grant college is representative of the widespread dissatisfaction which is voiced by some engineering deans and by the presidents of a few engineering colleges. "If our work is to be effective," says a dean in a state university, "we must have teachers with personality and some experience in the affairs of life. Furthermore, they must understand and sympathize with the family backgrounds and aspirations of the young men who compose their classes."

As the second quotation suggests, instructors in English are described as unwilling to become interested in the engineering stu-

* This is Chapter V of the Report on Instruction in English in Engineering Colleges.

dents. Moreover, they appear to their critics as not of a sufficiently masculine type nor of enough experience in the world outside their books to command the respect of engineering students. And there is a belief that the standards of selection are too low. One dean comments: "The standards of selection of an English instructor should be just as high as those for [the teacher of] a technical subject."

The conviction that their teachers of English are impractical, not masculine enough, and unsympathetic is also expressed by many engineering graduates. Sometimes their defects are ascribed to the post-graduate training of the English teacher. "Men trained in the graduate schools are most certainly unsatisfactory," writes an engineer from a Middle Western state university; "or at least the ones I had were. An instructor who glides into a class room and greets a class of engineers with a sweet schoolgirl smile and 'My, isn't this a beautiful spring morning?' hasn't a chance of teaching them anything." To one graduate his English instructor was "a budding pinko"; whereas he felt that "when a student embarks on engineering he has put aside—for a time at least—all ideas of revamping the social order and such-like." Engineering students and instructors in English are said to be cast in different molds; there can be no meeting of minds.*

Selection

The "practical" teacher. As a principal remedy for the prevalence of teachers of English who are effeminate, blind to the qualities and needs of the engineering students, and too narrowly interested in their special fields, many engineering deans and graduates suggest "practical" teachers. They think that the teaching could be improved if men with an engineering education, or at least with an engineering point of view, could be given special training for the purpose of teaching English to engineering students; or, the order of training might be reversed and an English teacher trained in the field of engineering. "I would say that we

* It is noticeable that most of these comments as well as others that will be found later in this chapter are based on the assumption that the engineering students are different from other students. What, if any, are the distinguishing characteristics of the engineering students? We have been told that they are practical, masculine, hard-headed persons with analytical minds, impatient with gush and emotion, unappreciative of poetry and the arts, which are regarded as feminine and sentimental. The conclusion drawn by some is that even the training in English must be adapted to these keen, hard, practical young men. Most teachers of English are agreed, however, that engineering students as students of English are not so different from students in a liberal arts college, if exception is made of the few liberal arts students who are specialists in literature or related fields, as to require a special kind of teacher.

must decide whether it would be better to have an engineer, well versed in English and its requirements in the field of industry, teach English or whether an English teacher be trained in the field of engineering," is one comment. "If I understand correctly the consensus of our engineering faculty," writes another engineering administrator, "it is that the function of a department of English in a college of engineering would be to train the students so that they could handle language effectively in their business. There is great unanimity in the belief that this could be done most effectively by teachers who were both engineers and teachers of English. It is also the belief that such teachers can be found and developed."

In their requirements for teachers of English the emphasis of engineering graduates is more on what they call "practical" knowledge than is that of the engineering administrators and somewhat less upon knowledge of engineering. They would like teachers with experience in industrial fields; practical men with knowledge of business or journalism; scientists or engineers with a background of writing reports, technical articles, and business correspondence. One graduate writes: "By all means find an engineer's English instructor from the ranks of engineers," but he adds that "a literary-minded engineer is a rare commodity" and "is impossible—like many an ideal." Many go farther and say that engineering training is not at all necessary. "The ideal instructor of English for an engineering college is a practical man who has had some experience in business and journalism," one man writes. "I do not think a knowledge of engineering or science is essential."

The "cultured" teacher. It would be misleading to imply that all or nearly all engineers or administrators are hostile to the usual "literary" type of instructor now found in the engineering college. Many deans and college presidents, as well as some engineering graduates, feel that what is needed is not a different type of instructor but a better instructor. The engineering administrators in particular have this attitude. "A man of enthusiasm and tact," writes one dean, "if he has knowledge of anything, can make himself interesting and work with others whose special field is different from his own, certainly on the elementary level of freshman English." And another head of an engineering school records his belief that "teachers of English to engineers should be discriminating if not (or and if possible) creative scholars in one or more fields of literature." Some presidents object vigorously to special teachers of English or a special kind of teaching of English for engineering students. They see no reason why either the teachers or the nature of the teaching should be different. An old

Eastern university reports that it has always followed the policy of giving students of engineering much the same training as students in the other undergraduate schools. "In their courses in literature many students of engineering are stimulated by being in contact with students whose courses are directed toward other than scientific ends." "There is a more healthy interest and more helpful competition," says the president of a state university, "in classes where engineering students work alongside those who are preparing for medicine, law, business administration, home economics, and the like." Some of these presidents and deans are inclined to ascribe the inefficiency of English instruction as much to lack of coöperation and support on the part of engineering faculties as to deficiencies in the English teachers themselves.

Some engineering graduates also oppose the "practical" or "engineering" type of instructor in English. In fact, an analysis of the replies to questionnaires shows almost equal numbers opposing and demanding the use of special instructors. There are engineering graduates who feel that "instructors in English should have an appreciation of the beauty in literature and poetry"; that they should be able to impress upon their engineering students "that a liberal education is to their ultimate advantage, and that in college they have time only for laying a broad general foundation." These graduates recognize that "engineering students are subject to enough technical pressure tending to atrophy their broader interests," and assert that "the instructor in English should be some one entirely removed from engineering knowledge, some one who thinks the world rotates around English and around literature." "Out of this," one states, "might come a happy balance for the strictly technical instructors, who as a rule have little regard for the English department."

Even an instructor of the dilettante type is described as "exceedingly helpful for the further enrichment of the engineering student's contacts with non-professional life." "The average engineering instructor, on the other hand, is either the sharp business-man type or else the bloodless variety; and exposure to the tired sophistication of the typical young English instructor provides not only a pleasant change but a heavy eye-opening shock." The graduates who make these replies apparently got something from their courses; or they took to them a background of greater culture than some of their fellows who looked only for immediate practicality. Perhaps the views of the more "liberal" engineering graduates can best be summarized by a quotation from the letter of a graduate who writes: "Instructors . . . should not be all of one type. Some should be schooled in the classics, others

should have some knowledge of engineering or science, and some others have a journalistic or business background."

Attitudes in different parts of the country and different types of institutions. The opposing opinions of engineering graduates and also of engineering administrators seem to reflect the backgrounds from which they came or the atmosphere of their institutions. In the replies to the questionnaires almost none of the graduates of Eastern colleges of engineering insist upon engineering training or practical experience for their teachers of English, or upon courses especially adapted to engineering students. Apparently they assume that the traditional literary training of the ordinary college student is suitable also for the engineering student. On the other hand, in the Middle West, and, perhaps to a still greater extent, in the Dakotas and Texas and other Western states, graduates feel strongly that engineers are a special type of persons and therefore require a special type of teacher of English in specialized courses.

A similar geographical difference of attitude is found among engineering administrators, although they generally demand that English teachers contribute to the "cultural" education of their students. Some of them, however, on the basis of the complaints they hear, are inclined to feel that "cultured" engineers would be more effective than the average product of a graduate school of English.

It may also be said that the complaints about instruction in English occur more frequently in the engineering colleges of large universities than in separate engineering schools or land-grant colleges, where technology is paramount. The reason appears to be that in the large universities the instructors are regarded as devoting most of their attention to the students in the college of liberal arts and taking the teaching of engineering students as a disagreeable "chore," whereas in engineering schools they must succeed with engineering students or confess themselves failures.

Approval of teachers of speech. There is little complaint about teachers of speech; and there is evidence that in general they seem more practical than teachers of composition and literature. As one president said, referring to his own institution, "It might be well if some of the introverts of the English staff had some of the qualities of the extroverts of the speech staff." Speech teachers, of course, have the advantage of becoming acquainted with students in the various extracurricular activities of debating, extempore speech contests, and dramatics, and in that way coming to a more friendly understanding with them. Moreover, almost all their teaching seems to have practical applications to the life

work of the engineer. Some instructors who teach both composition and speech report a more sympathetic reception in their speech classes. On the other hand, there is some complaint—voiced mainly by teachers of English—that teachers of speech overemphasize the psychology of salesmanship and practical results and neglect both correctness of expression and the esthetic and moral aspects of communication. Since there is relatively little expressed dissatisfaction with instructors in speech, however, consideration in this chapter will be given only to teachers of English literature and composition.

Some conclusions about who should teach English. After surveying the contradictory views about what an instructor in English should be, the reader may think it impossible to satisfy the engineering profession as a whole. But the possibility of some agreement is not so remote as may appear.

The principal suggestion for the improvement of English department staffs is the use of engineering graduates or of men with experience in business or journalism. In spite of some opinions to the contrary, most educators agree that it is neither desirable nor possible to form departments of English from engineering graduates. If the instructors are to be men with sufficient general cultivation and a training in English to command the respect of members of other departments, the engineering colleges cannot supply them. In the first place, the most capable engineering students, even when they show interest in writing and literature, do not want to become teachers of English. They are superior in engineering as well as in English; and the rewards of engineering loom much larger in their eyes than those of the most successful teachers of English. In the second place, the number of engineering graduates with ability to teach English is small. The letters received by the Committee on English from graduates, who are in the main superior graduates, show that. Also, the files of almost any head of a department of English prove that even the engineering graduates who do think they might like to teach English cannot write correct letters of application. And, when it is suggested that there might be a chance for them in departments of English if they would suitably prepare themselves by graduate training, few take the advice. Moreover, it would be just as impossible to recruit the ranks of teachers of English from journalism or business.

On the other hand, there is the commendable policy of certain institutions—the Iowa State College is one—of occasionally seeking instructors who have had engineering or other practical training or experience, and have also properly prepared themselves in

English by graduate study. One or two such instructors in a staff often do a great deal to bridge the gap between the English faculty and the engineering faculty, and they may teach effectively the advanced courses in technical writing. They contribute ideas to the department and help train the younger instructors who have had only the liberal arts college and graduate school education. But their number is small and is not easily increased.

Apparently the only practical way of increasing the number would be for departments of English and engineering deans to select from their engineering students a few who appear to have the necessary qualities, see that they are properly supported during a period of training, and then provide suitable positions in English departments for them with the assurance that if they are successful a satisfactory career lies ahead. But it would be contrary to experience to conclude that such men would necessarily become the best teachers of English in engineering colleges. Many of the most capable and successful of English teachers know nothing of practical engineering or business, and have had the most literary of apprenticeships.

If the instructors in English must for the most part be persons whose primary interest is literature, either in appreciation or creation of it, then it is apparent that we shall get farther by selecting higher grade men and women of the "literary" kind than by devoting much energy to the hopeless task of finding enough capable "practical" teachers. By "higher grade" teachers we should mean not better technical scholars but better teachers, those with the personal qualities that will make them significant and interesting human beings, even to the engineering students whose primary interests are not literary. They should also have the right attitudes for working with engineers.

Training

If it is agreed that instructors, whether graduates in engineering or not, must be trained in graduate schools of English, what sort of training is most desirable? At this point the engineering college administrators are not very helpful. A dean of a state university does say, "I believe there should be some place in the country where a student interested in teaching English in engineering schools might go for his graduate work and receive definite training for his work," but he does not indicate what that training should be. It would seem that some deans believe that a very little training in English would go a long way if the instructor knew some engineering. The director of a school of mines is apparently of this opinion, for he hopes that his institution "some day might find an

engineer . . . of broad training . . . who would be willing to forsake his engineering, brush up his English if necessary, and become a teacher of English in a technical school." Most administrators, however, believe that considerable training in English is necessary. One goes so far as to say, "The teachers of English in engineering schools should be holders of the doctorate, or they should have produced writings recognized as literature."

Objections to the Ph.D. training. Heads of departments of English have more concrete suggestions than the administrators, although some of them seem reasonably well satisfied with the present graduate instruction. One in a land-grant college writes: "The idea that graduate work in English unfits a man for teaching engineers is pure ignorance or prejudice, or both." On the other hand, a head in an Eastern technical college, well known for its successful work in English, says, "In this institution we all agree that 'the training which the average instructor receives in the graduate school rather unfits him for his work.' Of course the untowardness of the result depends upon the personality of the instructor. In general, the experience is simply poisonous. Some men, to be sure, can live down their Ph.D.'s, and are not permanently injured. But, for the life of me, I cannot see that the degree, or the training that lies behind it, is of the slightest use practically to a *teacher*. In general it is a serious handicap. Preach this from the housetops and so help to destroy a vicious delusion. Teachers are not made in this way or by this method. On the other hand, the instructor should have had several really useful graduate courses in literature or composition for at least a year at some first-rate university, and every few years, the young instructor should take an additional course or several courses. These broaden his interests, give him fresh material, a larger background." This departmental head rejects, however, the opinion that knowledge of engineering as such is necessary or even desirable. In fact he says, "I should shy away from it; that is, if it means that the instructor has specialized in engineering. That is just what we must avoid. A general knowledge of . . . what engineering means, of its methods, and some of its principal problems—yes, of course this is desirable, and even essential, as one goes on."

Still another departmental head is so distrustful of the graduate schools that, when looking for instructors, he has frequently engaged promising young men who have just been graduated from colleges of liberal arts. One disadvantage of this method is that it may leave the instructor tied to his engineering college, blocking advancement. But a number of heads of departments feel that training as far as the master's degree is ample. One writes that his institution "has long felt that the possession of a doctor's degree

was not necessary for effective teaching. That is particularly true in the field of English. . . . I think it well to urge instructors to secure the master's degree. Beyond that, experience in journalism or business will in my judgment prove more helpful than research for a doctorate." Another head writes: "I am convinced that a prospective teacher in an engineering school should have a thorough course in English through the M.A. But I think the Ph.D. grind in early English and related material is a sheer waste of time. Of course, I have no objection to the Ph.D. as a degree, but it does not qualify a man to teach engineers. I feel that after the M.A. the prospective teacher should have additional work in public speaking, journalism, the history of science, logic, art, and music, and bibliography."

On the other hand, a well-known teacher of English who has become an administrator believes that the graduate training to the doctorate is desirable: "In the light of my experience, both as a teacher and an administrator, I am convinced that graduate training in English is almost essential to success. When instructors with such a background have failed, they have failed not because of its character but because they would have failed under any circumstances."

Instructors should be trained to teach composition. Training in composition is recognized as of the greatest importance. As expressed by one department head, "Two qualifications should be required of an instructor in English for engineering students: the first is that he should have as thorough training in composition as in literature; and the second is that he should have sense enough to motivate his courses so as to gain the interest of his students." This writer feels that the way to insure better instructors in the college of engineering is not to have its instructors in English trained in engineering, in science, or in journalism, but instead to have them properly trained in English. He points out that "English for engineering students is essentially the same as English for any other students, particularly . . . in the elementary courses. If any specialization is needed, it is in some advanced composition courses that make special applications of English in the writing of technical articles or reports; but these special courses are not in themselves so important as they seem, and any intelligent instructor can easily make the application."

The complaint that the graduate schools fail to train teachers of composition is perhaps the one most often and most vigorously expressed. This complaint is not, in general, that there are no teacher-training courses, although such courses are occasionally recommended. It is rather that the students do not obtain the

fundamental knowledge of language that they will need when they become teachers. One head of a department writes that "we might well call on the graduate schools to see that their English men know much more than they do about contemporary English—about its rich and flexible grammatical system, about our inconveniently rich English vocabulary, about the levels of good English, about rational principles of usage, about our English consonants, vowels, and diphthongs, and about the interesting and important phenomena known as word accent and sentence stress. Too many college teachers of English are so ignorant of phonetics and so little acquainted with the great authorities of the English language that they cannot answer intelligently the questions about grammar and pronunciation that may come up in any freshman section at any time. A teacher who has spent valuable hours on the phonology and grammar of Old English may yet turn out to be ignorant of the three regional types of American pronunciation, of the difference between a diphthong and a simple vowel, or of the difference between a weak form and a strong form of a word that he uses a hundrd times a day. An English teacher who does not know the great grammarians such as Curme and Jespersen is a prey to the mistaken dicta of the little grammarians." *

The instructors in English who have written the Committee, most of them younger men, repeat these criticisms of graduate training. Graduate instruction in English, they say, fails to prepare the student to teach any work in composition. They propose that the prospective teachers have in their training "more practice in composition and criticism than they have, without having any less emphasis on literary history." "The Ph.D. training, and graduate training in general," writes one instructor, "ignores the fact that most of the products are going out to teach, not in the graduate schools of the country, but in the undergraduate schools and in the grade and high schools. Some graduate courses cannot help benefiting . . . teachers of courses in literature . . . , but there is scarcely a graduate course offered which will aid the teacher of composition. Curious, is it not, when every M.A. and Ph.D. is going to do considerable composition teaching before he arrives in the 'green pastures' marked 'literature only,' and when, according to our guess, at least 50 per cent of the English sections in colleges and 50 per cent of college teaching are in composition. . . . Surely somewhere along the way [the instructor] should get some training

* From a paper read before the Conference on English at the annual meeting of the Society for the Promotion of Engineering Education, College Station, Texas, 1938, by Professor George Summey, Jr. In this paper Dr. Summey also states emphatically that many teachers of English "cannot practice with decent skill the art they profess to teach."

in the teaching of composition: in methods of theme-reading; in methods of presenting, interestingly if possible, rules and regulations concerning grammar and punctuation and in any other kind of composition teaching he may be called upon to do; short-story writing, essay-writing, argument, exposition, magazine-article writing, report writing, journalism, and so on. In such a program, an extended study of linguistics, history of language, etc., might profitably be included."

The statement by the instructor just quoted that the graduate student has almost no teaching in composition is probably too emphatic. The writing of a thesis itself, if properly directed, is an excellent training in composition. And in the graduate schools there are a few courses in style, in modern usage, and in specialized composition that should directly aid a prospective teacher. On the other hand, it is exceedingly difficult to learn whether or not a candidate for an English instructorship is fitted for teaching composition, since recommendations from graduate schools are curiously uninforming in this respect. The assumption seems to be that a capable student of literature is sufficiently well prepared to teach composition. It is often difficult to learn whether or not a candidate for a position can write with reasonable skill and accuracy, although altogether too many letters of application at once reveal deficiencies or at least show a kind of carelessness that a composition teacher of merit is not likely to manifest. Recently graduate schools have been sending to heads of departments the names of their graduate students who are candidates for college positions with a brief statement regarding each student. Seldom is there reference to the candidate's skill in composition or to his probable ability to teach it.

Some graduate schools are made up largely of assistants who are spending part of their time in teaching freshman composition, and this teaching, which is usually directed by one of the mature members of the staff, is often called an apprenticeship. In some institutions there are occasional staff conferences, or there may be visitation of classes either for the purpose of evaluating the teaching or of giving suggestions for its improvement. That such training—if it can be called that—has some value cannot be denied. That it has proved to be a satisfactory training cannot be claimed. At least one engineering college hesitates to select instructors who have had this training. When the student's interests are divided between teaching and graduate work, the teaching is too likely to suffer, since the success of the teacher-student is primarily dependent upon his success as a student. Often students have gained a contemptuous attitude toward their teaching that continues after they have their degrees and are teaching in other institutions.

One engineering dean, well known for his interest in English teaching, writes that the practice of using graduate students as classroom teachers "can not be condemned too often or too strongly."

Conclusions

In all this confusion of opinion about the kind of teacher wanted and the sort of experience or training that will help to produce the right kind of teacher, recommendations that will commend universal assent are of course not possible. But certain suggestions would seem to have the approval of a working majority.

1. The personality, character, and general cultivation of the instructor are of primary importance. All sorts of persons with all sorts of training have succeeded admirably in teaching engineering students. Intelligence, alertness, sympathy, good manners, courtesy, industry, command of one's field, and wide knowledge will make one a good teacher whether or not he can talk intelligently about a power plant or has a command of physics.

2. It is desirable to enlist in the ranks of teachers of English a very small number of persons who have some knowledge of engineering or who have had practical experience in journalism or perhaps business. These men should also be well trained in English, although the Ph.D. may not be necessary for all. At least it should be possible for superior men to advance without the Ph.D. But it is neither necessary nor desirable that all or even a very large number of teachers should have had this engineering training or practical experience.

3. To succeed, however, in the present educational system the teachers of English should have a training that will command respect not only in engineering colleges but elsewhere. It is very doubtful if the engineering colleges alone can insure a future for many teachers of English. Often the teacher finds it necessary to transfer to the liberal arts college, and he should be able to do so. There is no reason, in fact, why the good teacher of engineering students should not be just as good when teaching students of commerce or agriculture or liberal arts.* Consequently, it is to be expected that many of our teachers will proceed as far as the doctor's degree if only to protect their own future.

4. There is no one set of requirements for a complete graduate education—that is, an education as far as the doctorate—that will be suitable for all, whether they are to teach in engineering colleges

* Although this report is limited to instruction in English in engineering colleges, it should be emphasized that most of the unfavorable criticism and many of the suggestions for improvement are applicable to the teaching of all kinds of undergraduate students, including those in colleges of liberal arts.

or not. But it is pretty obvious that certain training is likely to be helpful to the teacher of engineers:

(*a*) Probably most important at present is training that would equip the teacher of composition. Just what such training should be cannot be stated in this chapter. But the kind of training in language that is encouraged at the University of Michigan might well be stressed. Professor Marckwardt of that institution has made an excellent defense of language training in the course of which he remarks, "A Renaissance specialist, whether he likes it or not, will undoubtedly begin his professional career by teaching from one to three classes of Freshman composition. His chief efforts will be expended in attempting to establish the 'decencies' in the written and spoken language of his charges. In so doing, he will undoubtedly have to use textbooks which contain some truths about the English language, many more half-truths, and a good deal of palpable nonsense. To sift the truths from the nonsense requires a knowledge of the facts of present-day English and its development." †

A member of the Committee on English has also suggested that one part of the training should be teaching technical students under the supervision of a superior person who has proved his success. Certainly instruction in style and methods of analyzing writing should be included, for most beginning teachers of composition are quite ignorant of how to train students to improve their writing beyond the mere correction of mechanical errors.

(*b*) Prospective teachers should be well acquainted with the history of science, the history of art and music, the literature of the world, the history of philosophy, and trends in contemporary thought. A person with this broad training would command a respect from engineering students and teachers that the modern specialist is too likely not to have.

(*c*) Some ability to practice the art of composition should be manifested, as in the writing of a thesis, a critical work, or perhaps some creative work.

(*d*) Some believe that an acquaintance with physics or some phase of engineering would be desirable, and a few prospective teachers with the necessary aptitude might be encouraged in studies of this sort.

But it will be of little value to mention desirable qualities in teachers unless some concerted effort is made to produce teachers with these qualities. The following is suggested as one possible method:

† Albert H. Marckwardt, "Language Study in the Graduate English Curriculum," *English Journal*, XXVII (1938), 570–576.

(1) Select persons, perhaps persons who have just graduated from college, who have promise of becoming successful teachers of English in technical colleges. Some of them might be graduates of engineering colleges. Most of them evidently would not be. Some of them might be young teachers of English in the engineering colleges who have begun to show their worth.

(2) Outline with them a course of training that will be equal in difficulty to any other course, and, it is hoped, superior in value, with a view to making teachers of composition and teachers of literature for undergraduates. The plan should not be too rigid, for allowance must be made for the differences in individuals.

(3) See that scholarships or fellowships are made available for the training of these men, if necessary fellowships for more than one year, so that they need not delay their graduate work until they are middle-aged.

(4) Encourage students to go to graduate schools that are willing to coöperate in producing the kind of men desired. Perhaps it will be possible to use graduate schools where there is an engineering college or where there are neighboring colleges of engineering with staffs of English professors that can coöperate in the practical training.

(5) See that these men, when trained, are given an opportunity to use their abilities and are advanced as rapidly as their own growth justifies.

A somewhat less ambitious plan but one which has great possibilities is to establish a summer school for teachers of English in the engineering college. It has been suggested that such a summer school be held in an institution that can supply enough engineering students for practical demonstrations and a few of the most successful teachers of engineering students of the country be invited to direct the studies of the group. Perhaps some institutions would be willing to pay the cost of sending representatives for a period of six weeks or longer. Perhaps a few scholarships could be established. The work would be very practical and would include methods of teaching composition and literature and perhaps speech. There should be plenty of time for discussions as well as for lectures and demonstrations. If an institution with a good summer climate were selected, it should not be difficult to bring together from all parts of the country a small and enthusiastic group of persons who are vitally interested in making English a more significant part of engineering education.

To accomplish what is here suggested would require the cooperative effort of a considerable number of engineering colleges. It would require some money. But the results should more than repay the cost.

MECHANICAL ENGINEERING PAGE

Those who personally dominate are heroes for the hour; those who build men are immortals.

R. L. SWEIGERT, Georgia School of Technology, *Editor*

"DO INSTRUCTIONAL METHODS USED IN MANUFACTURING PROCESSING LABORATORIES CONTRIBUTE TO TRADE TRAINING OR TO ENGINEERING EDUCATION?"

This topic was the subject of an afternoon meeting of the Mechanical Engineering Division at Pennsylvania State College. The outstanding point observed at this meeting was the unanimity of opinion concerning the Manufacturing Processing Laboratories.

There seemed to be complete agreement on the objective of such laboratories. This objective is:

To give a knowledge of materials, and of the relation of manufacturing processes to these materials.

A large number of comments were made by men from widely scattered localities. Many of these comments should be of considerable value to those who are responsible for or concerned with the Processing Laboratories. The University of Michigan has been developing and using methods that are in line with the objective above. The first comments given here are those of Professor Boston of the University of Michigan:

"At the University of Michigan, Metal Processing is taught by coördinating design, metallurgy, and production. Production itself involves study, a knowledge of principles and judgment is gained which replaces the superficial skill acquired from the manual training type of course.

Laboratory work should be only a minor part of each course. It is to support well-organized and carried-out classroom work. For example, the weight given the laboratory work in the Machine Shop course at Michigan is only three-eighths of the total, two-eighths being based on three blue-books and eight short class writtens, one-eighth on approximately eight problems, and two-eighths on the final examination.

Laboratories are most essential in the elementary or basic courses. The exercise method should be used rather than projects involving a complicated mechanism, such as engines, machine tools, etc. In the former, each laboratory period has a specific case or exercise to demonstrate the particular principle involved. The project method may emphasize too strongly the building of an object and result in repetition with too little variation in type of work.

The generally required courses in Metal Processing given at the University of Michigan are as follows:

Metal Processing 2, the Working, Heat Treating, and Welding of Steel, involves one one-hour classroom period based on assignments from a text and one three-hour laboratory period for a total of two credit hours.

Metal Processing 4, Machine Shop, also has two one-hour classroom periods and two three-hour laboratory periods a week.

Metal Processing 2 is regularly scheduled with the theoretical course, Chemical Engineering 1, during the second semester of the freshman year or

the first semester of the sophomore year. Foundry and Machine Shop are scheduled during the junior and senior years.

Metal Processing laboratories are not shops according to my own accepted nomenclature. They are laboratories. They function to illustrate, permit demonstrations, and offer an opportunity for some practices on which judgment may be based—just as a laboratory for physics, chemistry, or engineering mechanics. I would emphasize coördination as the main purpose of these laboratories, as I believe when properly used, they furnish excellent opportunities of this nature. Our own Metal Processing laboratories are used also in many advanced Metal Processing courses, such as Advanced Machine Shop, Advanced Foundry, Advanced Metal Working, Welding, Aircraft materials and construction, Gaging and Measuring, Machinability, Jigs, Fixtures, Die Design, and Machine Tool Design. Even Time Study and Plant Layout and similar subjects may be included in this list.

A mechanical engineer should be able to select materials for a design, and, knowing the material which best will meet the physical, chemical, and thermal requirements, select the best available form for fabrication. He should be able to determine the treatment and fits so that each part may be manufactured in small, intermediate, or large quantities at the least cost. This is not a question of trade skill, but rather an understanding of principles. Industrial practice after graduation will develop skill which will make the graduate a more valuable man in industry.

Most Metal Processing laboratories are under the general supervision of men who do not appreciate the full advantages that can be made of them. The time is coming soon when such laboratories will have to be used more effectively. They then will demand greater respect than at present.

Many students enjoy the use of laboratories in the pursuit of a hobby. This type of work certainly should be encouraged when possible. Frequently, students taking courses in Metal Processing have their first contact with this kind of work. Many of them, for the first time see the type of work in which they wish to specialize and earn their livelihood.

To conclude these brief comments, I would refer to the title, "Do Instructional Methods Used in the Manufacturing Processes Laboratories Contribute to Trade Training or to Engineering Education?" and answer in the affirmative in both cases. Their justification, however, should be based on their contribution to engineering education."

Notice to Members of the M. E. Division of the S. P. E. E.

There is to be a joint luncheon meeting of the M. E. Division of the S. P. E. E. and the A. S. M. E. at the Philadelphia meeting of the A. S. M. E. which is being held from December 4–8. This meeting will initiate a closer relationship between the S. P. E. E. and the A. S. M. E. which should be of benefit to both. It is hoped that every member present at the Philadelphia meeting will attend this joint meeting. The speaker will be F. T. Hague, Manager of Engineering, South Philadelphia Plant, Westinghouse Company. The luncheon meeting will be held Tuesday, December 5, in the Oak Room of the Bellevue-Stratford Hotel.

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

A. W. LEIGHTON, *Editor*, Tufts College

A METHOD OF GRADING USED IN A MECHANICAL DRAWING COURSE

The young drawing instructor, feeling his way with caution, desires some means of evaluating his work, of comparing it with the work of others, of getting the criticism or commendations of his older colleagues. He is fearful lest he become smug in his sense of accomplishment when he has accomplished little. He wants to progress with confidence.

The time of greatest uncertainty is the period near the end of the semester, when, in assigning grades to his students, he is, in a sense, assigning a grade to himself. Then it is that he wants the counsel of one wiser than he. Yet he does not ask for counsel, because he has found that counseling is so often merely a difference of opinion; or he finds that the would-be counselor is a man who says, "I did so-and-so. Go thou and do likewise." Such is the situation of the new instructor.

His superior, the head of the department, wonders how the young man is getting along. Is he holding the standards sufficiently high? Is he going far afield in the subject matter? Will his grades be a valid measurement of the progress of the student? Or will they be "padded"? Is he a teacher or an assignor of work? Is there justification for giving him more responsibility, or should he be gently guided to some other field of activity?

This article is a description of a method of grading which has helped to orient and develop instructors of freshman drawing in one engineering college. The personnel of the department consists of the chairman, two instructors, four graduate assistants and three student assistants. The time of the assistants is divided between the instructors. The instructor, in turn, is solely responsible for the instruction and administration of the classes which the chairman has assigned to him, except for the final grading.

The determination of the final grades in all the freshman courses is accomplished by the chairman and the two instructors, working in coöperation. One drawing section is graded at a time. The plates are placed about the room, one set to a table. Each man examines the work of each student and records on a prepared blank the grade that he judges the student has earned. The grades are letter grades, with a plus or a minus when desired. Each man grades according to his own standards, whatever they may be, except that his grade is not to be influenced by the quantity of work completed.

When each man has completed his first step of grading the three come together for the second and final step. The grade of each individual student is considered separately. If the grades given by the three men substantially

agree, and the instructor of the student indicates that all the required work is completed, no further consideration is required. The final grade is recorded as "A," "B," "C," "D," or "F." If the average of the three grades falls about half way between two of the straight letter grades, further and more lengthy examination of the student's work is called for. Then, if the question is not settled, the grade of the instructor concerned assumes more weight, and the final grade is thus determined. If the student has not completed all the work, the application of policies and/or discussion will determine if the student will receive a passing grade, an "F" (failure), or an "I" (incomplete).

In the ten years that the present grading procedure has been in use, the following points have been observed:

1. The students are satisfied with the fairness of the method.
2. The instructor is glad to be relieved of the sole responsibility of grading.
3. Time is saved. The combined time of three men going through the drawing plates is less than the time that would be required for one man to grade them reliably, either all at one time at the end of the semester, or by grading each plate at the time it is submitted.
4. The effect of personal friendship or antagonism between instructor and student is minimized.
5. The student's attitude of "working for a grade" is minimized. Instead, he works to eliminate errors as pointed out to him on each plate.
6. The time of the instructors and assistants can be devoted more fully to the teaching of the subject and less to the giving of grades.

In this system of grading, three viewpoints are represented:

1. The instructor of the students can use his knowledge of the students' attitudes, efforts and handicaps.
2. The other instructor and the department head, not being acquainted with the students, bring to bear an unprejudiced judgment.
3. The head of the department brings to bear the long-term viewpoint. His is a stabilizing influence.

GEORGE B. SMITH,
Instructor in Technical Drawing.

COLLEGE OF APPLIED SCIENCE,
SYRACUSE UNIVERSITY.

NECROLOGY

GEORGE HUGH SHEPARD, Professor of Industrial Engineering and Management at Purdue University, passed away July 30, 1939. He was the son of Dr. Gilbert and Helen (Coman) Shepard and was born December 28, 1870, at Tremtealeaw, Wisconsin. After his graduation from the Eau Claire high school he entered the United States Naval Academy in 1886 from which he graduated as Ensign in 1891. He served in the Navy until he was retired because of an injury received in the line of duty. Throughout his career he retained the viewpoint of a patriot in the service of his country.

Continuing his education he received an M.M.E. degree at Cornell in 1902 and remained at that institution four years until 1906 when he went to the University of Syracuse for nine additional years as a teacher. He was for six years consultant and member of the firm of Harrington and Emerson, pioneer industrial engineers.

With the outbreak of war in 1917 he returned to active naval duty, serving as efficiency engineer at the Norfolk Navy yard with rank of lieutenant-commander until he joined the Purdue staff in the fall of 1919 as Professor of Industrial Engineering and Management.

In his thirty-five years as teacher he continuously championed the cause of industrial effectiveness and, more important still, the cause of personal efficiency on the part of his students. To many thousands of young men he brought home the necessity of so budgeting time that a full and satisfying life could be lived on twenty-four hours a day.

He was the author of two volumes, "Industrial Management" and "Industrial Engineering," and also the contributor of numerous articles to engineering publications. He was a member of the International Committee on Fatigue, National Board of the American Society of Industrial Engineers, American Society of Mechanical Engineers. He was also a member of Phi Gamma Delta, Tau Beta Pi, Pi Tau Sigma, Sigma Xi, Scabbard and Blade, Navy Club, American Legion, Parlor Club and Saint John's Episcopal church.

In the passing of Professor Shepard, July 30, 1939, the Society has lost an experienced and effective teacher and a colleague with an unusual record of duty well done.

COLLEGE NOTES

Armour Institute of Technology.—It was announced by James D. Cunningham, Chairman of the Board of Trustees of Armour Institute of Technology, and Alex. D. Bailey, Chairman of the Board of Lewis Institute, that their respective institutions had entered into an agreement to consolidate into a great new technological center for Chicago. This is the first occasion on which two colleges of engineering have ever agreed to merge their interests to produce an institution of more important scope.

The name of the new school is to be Illinois Institute of Technology, with the background and reputation of the two component colleges recognized by maintaining their names as applied to its two divisions. Armour and Lewis have for many years served the community in the fields of engineering education, and, by this amalgamation, it is expected that this work and this service can be greatly enhanced to the benefit of the community. The general effect will be to produce for Chicago a technological institution second to none in this country.

The actual consolidation of the educational program will be complete by September, 1940, and the balance of this year will be given over to planning an integration of activities. For the time being, it will be necessary to operate both the Armour and Lewis plants, but the complete development of the new center of technology contemplates the acquisition of a new, well-planned campus, conveniently located, to meet the needs of its broad objectives.

Illinois Institute of Technology will be controlled by a Board of Trustees of fifty-five members, made up of the present trustees of both Armour and Lewis.

Alumni of **Case School of Applied Science** in an effort to interest a larger public in the problems of privately supported colleges of engineering sponsored a nation-wide radio broadcast on Saturday, October 28, in the course of which six industrialists and scientists discussed the question, "What's Ahead for the Privately Endowed College of Engineering?" The discussion was carried over the coast-to-coast facilities of the Mutual Broadcasting Company.

George S. Case, chairman of the Board of Lamson and Sessions Company, will act as chairman, and the following actively participated in the discussion: Zay Jeffries, technical advisor, General Electric Company; Randolph Eide, president, Ohio Bell Telephone

Company; Lee M. Clegg, executive vice-president, Thompson Products Company; David Dietz, science editor, Scripps-Howard Newspapers, and Sam W. Emerson, president, Sam W. Emerson Company, contractors.

University of Illinois.—A. C. Callen, Professor of Mining Engineering and Head of the Department of Mining and Metallurgical Engineering since 1924, resigned on September 1 to become Dean of Engineering and Head of the Department of Mining Engineering at Lehigh University. For the current year, H. L. Walker is in charge of the Division of Metallurgical Engineering, and H. P. Nicholson is in charge of the Division of Mining Engineering. A. B. Wilder, Assistant Professor of Metallurgical Engineering, resigned on September 1 to accept a position as Research Engineer for the Jones & Laughlin Steel Company, Pittsburgh, Pennsylvania. John Louis G. Weysser, formerly Research Mining Engineer for the Lehigh Navigation Coal Company, came to the University this year to become Assistant Professor of Mining Engineering. P. G. Kruger, Professor of Physics, is on sabbatical leave for the first semester of the current year to engage in research work in the field of nuclear physics at the University of California, at Berkeley.

There were several promotions among the members of the faculty. Those advanced to the rank of professor were as follows: H. A. Brown, J. O. Kraehenbuehl, and H. J. Reich from Associate Professor to Professor of Electrical Engineering; W. N. Espy from Associate Professor to Professor of Mechanical Engineering; H. F. Johnstone from Associate Professor to Professor of Chemical Engineering; and P. G. Kruger from Associate Professor to Professor of Physics. Those promoted to the rank of associate professor were as follows: G. M. Almy and H. M. Mott-Smith, Jr., from Assistant Professor to Associate Professor of Physics: D. G. Ryan from Assistant Professor to Associate Professor of Mechanical Engineering; H. J. Schrader from Assistant Professor to Associate Professor of Railway Mechanical Engineering; and M. K. Fahnestock from Research Assistant Professor to Research Associate Professor of Mechanical Engineering. In addition the following were advanced to the rank of assistant professor: W. L. Collins of the Department of Theoretical and Applied Mechanics; S. G. Hall of the Department of General Engineering Drawing; L. J. Haworth of the Department of Physics; J. R. Fellows and C. E. Schubert of the Department of Mechanical Engineering; and W. H. Bruckner, to Research Assistant Professor of Metallurgical Engineering.

University of Kansas.—Samuel Eugene Clements has been appointed instructor in Electrical Engineering. He will have charge of the communication laboratory and will teach courses in communication. Mr. Clements is a graduate of the Electrical Engineering department at Yale University, where he obtained his master's degree in June 1938. During the past year he was an instructor at Iowa State College, Ames, Iowa. Mr. Clements succeeds E. W. Hamlin, who resigned to take a similar position with the electrical engineering department at the University of Texas.

For some time the engineering drawing department has been in need of an additional full-time instructor. This need has been satisfied by the appointment of Albert S. Palmerlee, who graduated from North Dakota Agriculture College in 1929. He holds a master's degree in mathematics from the University of Kansas, 1933, and a mechanical engineering degree from the same school in 1939. Mr. Palmerlee's practical experience includes two years as a teacher of high school mathematics, four years as a half-time instructor in mathematics at the University of Kansas, one year as an instructor in an evening vocational school, and three years as a commanding officer of a CCC camp.

Advanced to the position of instructor in Chemical Engineering is Donald A. Spalding. He served as an assistant instructor in the Chemical Engineering department of the University of Kansas during the second semester of last year. Mr. Spalding received his B.S. in chemical engineering from Kansas in 1939. For some time he was with Proctor & Gamble Soap Company in Kansas City, Kansas.

The department of applied mechanics is installing a laboratory for the study of photo-elasticity. A polariscope having an 8-inch field, utilizing Polaroid in the polarizing and analyzing units, has been purchased. It is expected that the laboratory will be completed during the present school year, and that it will be used in the near future for class instruction and for research. The department has also ordered a new 60,000 lb. hydraulic, universal testing machine for its materials testing laboratory.

Massachusetts Institute of Technology.—In addition to new appointments previously announced, several other new men have been added to the Institute Faculty. Sverre Petterssen, the distinguished Norwegian meteorologist, is to have charge of the Institute's division of Meteorology during the leave-of-absence of C. G. A. Rossby, who is now assistant-chief for research and education, of the United States Weather Bureau in Washington.

A new member of the department of Metallurgy is Antoine M. Gaudin, internationally recognized authority on process metallurgy,

who becomes Richards Professor of Mineral Dressing. He comes to the Institute from the Montana School of Mines, where he won an international reputation for metallurgical research of far reaching importance.

Promotion of Charles S. Draper, authority on airplane testing devices and flight instruments, to the rank of professor of aeronautical engineering has just been announced effective with the coming academic year. In addition, Flavel Shurtleff of New York City has been made an assistant professor of city planning; Professor F. L. Foster of the Department of Mining Engineering has been made assistant to the director of the Division of Industrial Cooperation; Lieutenant Commander Richard M. Rusch has been appointed a special lecturer in naval architecture, and W. L. Whitehead as a special lecturer in mining engineering.

The Institute has lost through resignation Horace T. Mann, associate professor of mining, who has gone to the University of Missouri School of Mines.

C. L. Norton, since 1921 Director of the Division of Industrial Coöperation and for a number of years Head of the Physics Department, died early in September.

The Institute's facilities have been increased by the addition of the new and attractive Briggs field house on the athletic field west of Massachusetts Avenue. This, with the new track, will be used for the first time at the opening of the academic year.

Construction has been started on a swimming pool unit of the new Alumni Gymnasium. The building is to house two pools, one $75' \times 42'$ and another for instruction purposes, $20' \times 40'$. It is to include a second floor with spectators' gallery arranged at a forty-five degree angle, a complete and novel filtration equipment, panel heating, and fluorescent lighting. Completion is expected in June 1940.

A fund has been established at the Institute for solar energy research. At present this program is divided into four main branches: heat engines and storage, photochemical effects, photoelectric effects, and thermoelectric effects. In connection with the first of these, a building has been constructed with large storage reservoir beneath it in which the heat collected on the roof (of suitable construction) will be stored for heating and refrigeration.

A cyclotron of 42″ pole-face has just been completed by the Physics Department, utilizing the coöperation of members of the staffs of other departments, and several industrial organizations. A number of important advances have been made in design. The instrument is housed in a new laboratory building where elaborate provision has been made for the protection of the operators from the biological effects of its radiation. At the present time the cyclotron

is being tuned and it is expected that it will be in operation shortly. The cyclotron is designed to operate in the range of 10 to 15-million-volt deuterons.

Due to the prospect of expansion in naval and merchant ship building, the Institute is offering for the first time this year an advanced course in marine engineering. While the course is designed primarily for graduates of Annapolis, five selected civilian graduate students will also be permitted to enroll.

North Carolina State College.—Enrollment for the fall term in the engineering school shows an increase of 23 per cent in the freshman class, and an increase of 14 per cent in all classes. Largest departmental gain is in the aeronautical school, now further expanding its operations under the C.A.A. The allotment of federal funds this year will provide for fifty students. The physics department is working with the aeronautical department by providing instruments and lectures for the study of meteorology. It is also expanding those services by the study of methods now in use at Purdue and at M. I. T.

The mechanical engineering department is increasing its facilities for graduate study. It has recently completed installation of a complete hydraulic test unit, which contains a scale model of the huge turbines designed by the Newport News Shipbuilding Corporation for the Russian government. The unit has also a towing basin and flume for experiments. The department has under construction a wind tunnel, and has recently installed two dynomometers for testing internal combustion engines.

For the electrical engineering department E. W. Winkler has recently reorganized the standards laboratory, with new equipment and methods of testing. K. B. Glenn has done extensive work in thermionics. The chemical engineering department is soon to have a whole building, as the department of general chemistry, formerly housed with chemical engineering, is moving into its own building, now nearing completion.

The new department of general engineering is open for the first time this year, with 31 entering students.

Additions to the faculty include, in the department of chemical engineering, William Allen Bain, B.S., N. C. State, M.S. and doctoral candidate, University of Wisconsin; and Thomas C. Doody, B.S., M.S., Ph.D., University of California. These men replace D. B. Wicker, who enters private enterprise; and W. G. Van Note, who is on leave for graduate study at Pennsylvania State College. To the physics department comes George E. Grouch, B.S. Furman, M.S., Vanderbilt, Ph.D., North Carolina. Other new instructors are: J. T. Massey, B.S. in E.E., N. C. State, department of engi-

neering mechanics; F. E. Mask, B.S., N. C. State, mathematics department; W. W. Kriegel, B.S. in C.E. and in Cer.E., University of Washington, M.S. in Cer.E., Montana School of Mines, and Dr. Ing., Technische Hochschule, Hannover, Germany, in the ceramics department; F. C. Williams, B.S., N. C. State, B.S., Illinois, in the department of architectural engineering. C. W. Maddison replaces his son, R. J. Maddison, as instructor in forge. The younger man is on leave in private industry. Also to the mechanical engineering department comes R. C. Walter as teaching fellow. F. F. Groseclose is transferred from the mechanical to the industrial engineering department.

The local branch of the S. P. E. E. now has 71 members, including two from the administration, two from the department of English, and one from the department of ethics and religion. The 66 members from the engineering faculty compose 87 per cent of that body. The group recently authorized its own membership in the North Carolina Engineering Council, a clearing-house organization for all engineering societies in the state. The engineering school is also joining those in active engineering practice through the student publication, *The Southern Engineer*.

The mathematics department is soon to be given its own quarters in the remodeled textile building. A new textile building is a part of the $1,600,000 expansion program, now nearing completion.

The Board of Trustees of **Northeastern University** has accepted the resignation of Frank Palmer Speare, founder and president of Northeastern for the past forty-two years, and has elected as his successor Carl Stephens Ell, formerly vice president of the University and dean of the College of Engineering. Dr. Ell joined the staff of Northeastern in 1909 and since 1917 he has served as dean of the College of Engineering and director of the entire Day Division program of the University.

Under his direction the College of Engineering has grown from an enrolment of eight students to be one of the largest engineering schools in the country. He has been responsible, too, for the development of the coöperative plan in the college which now has some three hundred coöperating companies along the Atlantic seaboard. Dr. Ell's election to the presidency is especially gratifying to the engineering faculty who look forward with confidence to an effective and sympathetic administration of the work of the engineering college under the new regime.

Dr. Ell received an A.B. degree from DePauw University in 1909, an S.B. from Massachusetts Institute of Technology in 1911, an M.S. from the same institution in 1912, and an Ed.M. from

Harvard in 1932. DePauw University honored him with the degree of Sc.D. in 1935.

He is a Fellow of the American Association for the Advancement of Science, a member of the American Society of Mechanical Engineers, American Society of Civil Engineers, Boston Society of Civil Engineers, the Engineering Societies of New England, the Harvard Teachers' Association, the Massachusetts Schoolmasters' Club, the New England Association of Colleges and Secondary Schools, the Massachusetts Civic League, and the Boston Chamber of Commerce. He has long been active in the Society for the Promotion of Engineering Education and at the present time is chairman of its Committee on Instructional Methods and a member of the Committee on Sections and Branches.

Dr. Ell is vice president and trustee of the New England Deaconess Hospital, and a trustee of the Newtonville Methodist Church. He is also a member of Phi Delta Kappa, Delta Upsilon, and the University Club of Boston. He is permanent president of the New England DePauw Alumni Association.

Dr. Ell will take office next June when Dr. Speare will become president emeritus.

Oregon State College.—The School of Engineering has experienced a substantial increase in enrollment this year, with a total of 975 students registered as compared with 875 for the Fall term of last year. This is an 11 per cent increase. The registration as to classes, and the per cent increase for each class over last year is as follows: Freshmen and Sophomores, 16 per cent; Juniors and Seniors, 8 per cent.

In the department of Civil Engineering, G. W. Holcomb was promoted from associate professor to professor of civil engineering. In addition to other duties, Professor Holcomb is in charge of the engineering courses given to freshman students. The leave of absence of F. G. Robley, who is pursuing graduate work at Yale, was extended for a second year.

E. A. Murray with an advanced degree in chemical engineering from the University of Washington has joined the department of Chemical Engineering at Oregon State College as an instructor. During the summer vacation period, members of this staff were engaged in consulting and research activities.

In the department of Electrical Engineering, F. A. Everest was promoted from instructor to assistant professor, B. H. Nichols from assistant professor to associate professor, and E. C. Starr from associate professor to professor of electrical engineering. During the summer vacation period the staff of this department were employed by the local utilities, and in research and technical writing.

Two graduate assistants, Messrs. Bruce Wells and F. H. Dickson, were added for the coming school year.

C. E. Thomas of the department of Mechanical Engineering attended the "Professor's School" conducted by the General Electric Co. in Schenectady, investigating in particular materials and metallurgy. B. F. Ruffner spent a part of the summer with the aeronautical engineering faculty of the University of Minnesota. He will have charge of the Civilian Pilot Training Program at O. S. C. Other members of the department engaged in research and made various trips to points of professional interest. T. R. Palmerlee of Kansas State University has joined the staff as an instructor, and Messrs. J. T. Doan (Purdue), W. R. Cherry (North Dakota) and M. N. Popovich (Oregon State) will be graduate assistants.

In the department of Industrial Arts, two instructors, Messrs. A. A. Robley, and M. C. Sheely, were added to the staff.

Two Engineering Experiment Station projects were quite active during the summer, a study of dry kiln fans by S. H. Graf and A. D. Hughes of the Mechanical Engineering Department, and a study of paint discoloration in certain western woods by E. G. Locke of the department of Chemical Engineering. Two engineering experiment station bulletins, one on testing electric fence controllers and the other on precipitation static interference on aircraft, are in preparation.

Purdue University.—New appointments to the engineering staff include: Mechanical Engineering: V. W. Antuchko, P. S. Collier, R. L. Dickinson, F. J. Gunther, A. S. Hall, C. W. Phelps, E. H. Pietsch, M. C. Wakefield, T. K. Sanders. Electrical Engineering: G. E. Mueller, R. Webb, C. G. Hylkema. Chemical and Metallurgical Engineering: J. Eckel, J. C. Lottes, R. J. Raudebaugh, G. W. Stewart. Civil Engineering: P. Johnson. General Engineering: C. Mock.

Enrollment in the engineering schools and departments of the University has reached a total undergraduate figure of 3,680 as compared with 3,611 last year. The Freshman number 1,226 of this years total. The distribution of students other than Freshmen in engineering is as follows: in Chemical and Metallurgical Engineering, 414; Civil Engineering, 203; Electrical Engineering, 490; Mechanical Engineering, 1,259; Public Service Engineering, 73; Engineering Law, 15. In the entire University the enrollment has reached a record figure of 7,121, an increase of 5 per cent over last year. Graduate students in engineering are over 100.

Completion of the new Chemical and Metallurgical Engineering Building (described in the November, 1938, issue of the JOURNAL) made room for expansion of the Applied Mechanics and Hydraulics instruction into the quarters formerly occupied by the Chemical group in Heavilon Hall.

The vacated Metallurgical laboratory building has been assigned for use as a heat transfer laboratory. Apparatus for the study of the viscosity of gases and of heat transfer in heating and ventilating apparatus and the conduction of heat in metals is being assembled there.

University of Southern California.—On September 18, with the opening of the fall semester, the College of Engineering moved into the new Engineering Building. This building, which will ultimately be used purely for laboratory purposes, also houses, for the present, classrooms and offices as well as the principal engineering laboratories. As fast as the new quarters are ready, the laboratories are being moved from our old quarters. It is expected that all of the new laboratories will be housed in the new building by the end of the semester. The building is of reinforced concrete, four stories, including a half basement, and is exceedingly well lighted and ventilated. Heavy equipment will be installed on the first two floors, and other laboratories are housed in the upper stories. The building is about 136 feet long and 50 feet wide.

New members of the engineering staff include Hugh G. Conley, Instructor in Civil Engineering. Mr. Conley is a graduate of the College of Engineering here in 1934 and has spent five years in engineering work with the Shell Oil Company and the Department of Building and Safety of the County of Los Angeles. Wm. H. Shallenberger, Instructor in Mechanical Engineering, was graduated from Stanford University of 1934. He has since done graduate work at Pennsylvania State College and the University of California. He was assistant Professor of Mechanical Engineering at "Texas" for one year and was for one year connected with the Shell Oil Company in Martinez. Paul Carnes, B.S. from the University of Montana, is a teaching Assistant in Chemical Engineering. Frank B. Herald, A.B. from the University of California at Los Angeles, is a teaching Assistant in Petroleum.

John F. Dodge, Head of the department of Petroleum Engineering, has been given a part-time appointment to become technical advisor to the United States Navy Department in connection with the development of petroleum reserves in California.

Syracuse University.—William E. Renner, of Schenectady, N. Y., Cost Reduction Engineer of the General Electric Co., has been

appointed Assistant Professor of Administrative Engineering. His special responsibility will be in connection with instructional and guidance work for students in Administrative Engineering. Professor Renner received his secondary education at the Utica Free Academy and was employed for two years in the advertising department of the International Heater Co. of Utica, N. Y. Later he enrolled at the University of Michigan, from which he received two degrees—one in Naval Architecture and Marine Engineering, and the other in Mechanical Engineering. His academic honors include election to Tau Beta Pi, Sigma Xi, and Phi Kappa Phi. He is affiliated with Lambda Chi Alpha fraternity. Following his graduation in 1927, Professor Renner has been continuously associated with the General Electric Co. at Schenectady, where he began his engineering career in the testing department. This was followed by research assignments in heat transfer and refrigeration development. For the past six years his time has been devoted to the economic aspect of design and factory contact problems and, in coöperation with the factory organization, to studies effecting cost reduction by the introduction of new materials and new methods of manufacture.

Nelson F. Murphy, of Queen's Village, L. I., N. Y., has been appointed Assistant Professor in Chemical Engineering. Dr. Murphy attended the public schools of Cincinnati, O., and then completed the five year coöperative course in Chemical Engineering at the University of Cincinnati. In connection with his school program, he was employed for four years by the Proctor and Gamble Co. where his duties comprised work in the plant and laboratory. Later he enrolled in the Graduate School at Cornell University where he received the degree of Ph.D. in 1934. His thesis, under the guidance of Dr. W. D. Bancroft, was on the subject of "Oxidation and Reduction Potential of Hydrogen Peroxide." For the past five years, Dr. Murphy has been on the chemical engineering staff of the General Chemical Company in New York City, where his work has had to do chiefly with process development and general research.

John O. Eichler, of Stony Creek, N. Y., has been appointed Instructor in Civil Engineering. He attended the public schools and Brooklyn Preparatory School in that city and afterwards enrolled in New York University, from which he was graduated with the degree of B.S. in Civil Engineering in 1930. He later registered in the Graduate School of New York University and completed courses in Educational Psychology. He is a member of Pi Kappa Alpha fraternity. For the past nine years Mr. Eichler has been in active engineering practice as Engineer and Superin-

tendent of Construction for John McKeefrey, Inc., building contractors of New York City. His range of experience covers factory, warehouse and residential construction, and the development and improvement of large estates in Westchester County and Long Island.

Villanova College.—Francis J. Limacher was appointed Assistant Professor of Chemical Engineering and takes over the work of William Haltenberger,, Jr., who has returned to the University of Michigan to continue his graduate work. Mr. Limacher received his B.S. in Ch.E. in 1933 from Oregon State College and his M.S.E., in 1937 from the University of Michigan and has done some graduate work at Purdue. He has spent some time in industry with the Roma Wine Company of Lodi, California, and the Reilly Tar and Chemical Corporation of Indinapolis, Indiana.

Rev. John Crawford, O.S.A., has returned from Johns Hopkins, where he has been doing graduate work in Physics, to take charge of Physics for the Arts students, thus relieving the load in the Engineering School.

Rudolph Drenick has also been added to the Engineering Staff as Instructor in Mathematics and Physics. Dr. Drenick received his Ph.D. from the University of Vienna in March, 1939.

Biographical Directory of Leaders in Education.—Jacques Cattell of the Science Press is gathering data for the forthcoming second edition of the Biographical Directory of Leaders in Education. As is more or less inevitable, there were many important omissions from the first edition and an unusually high percentage of those omissions was from among the engineering educators. If, therefore, you have received a questionnaire, Editor Cattell hopes you will fill it out and return it to him promptly.

SECTIONS AND BRANCHES

The **Allegheny Section** will hold its next annual meeting at the Carnegie Institute of Technology, October 25 and 26, 1940. The theme of the meeting will be The Coördination of Engineering Curricula. The new officers for 1939–40 are Emerson Pugh, Chairman, F. C. Stewart, Vice-Chairman, and J. B. Rosenbach, Secretary.

The Engineers' Council for Professional Development will meet in Pittsburgh, October 24, 1940, and have been invited to attend the meeting of the Allegheny Section.

The fifth annual meeting of the **North-Midwest Section** was held October 21–22, at the State University of Iowa, with J. R. DuPriest, Vice-Chairman, presiding. 278 members and guests were registered. The following program was presented: Teaching Engineering Physics, by C. J. Lapp, Associate Professor of Physics, State University of Iowa, and Chairman of Committee on Physics Examinations, American Association of Physics Teachers. Pre-testing in College Mathematics, by E. W. Chittenden, Professor of Mathematics, State University of Iowa, and Chairman of Committee on Tests of the Mathematical Association of America. Engineering Drawing by Thomas E. French, Professor of Engineering Drawing, The Ohio State University.

The dinner was held in the Iowa Memorial Union, Dean F. M. Dawson, toastmaster. The University Highlanders entertained and H. J. Thornton, Professor of History, State University of Iowa, spoke on The Industrialization of the South.

On Saturday, the following group conferences were held:

1. Physics: How to Develop the *Wish* to Learn Physics. G. W. Stewart, State University of Iowa, presiding. *Iowa State College*—J. W. Woodrow. "How to Develop the *Wish* to Learn Physics." *Marquette University*—Joseph F. Carroll. "How to Develop the *Wish* to Learn Physics." *Michigan College of Mines and Technology*—F. L. Partlo. "Should Modern Applications of Physics Be Permitted to Overshadow the Fundamentals." *University of Minnesota*—J. W. Buchta. "Modern Physics, and the Interest of Students in the First Course in Physics." *University of Wisconsin*—L. R. Ingersoll. "Developing the Engineering Student's Interest in Physics."

2. Mathematics: E. W. Chittenden, State University of Iowa, presiding. Continuation Courses in Mathematics for Engineers, I. S. Sokolnikoff, University of Wisconsin. The Relation of Physics to the Teaching of Calculus, J. V. Atanasoff, Iowa State College. Round Table Discussion: Methods of Integration of Courses in Mathematics, Physics, and Mechanics.

3. Chemical Engineering: O. A. Hougen, University of Wisconsin, presiding. Synopsis of Penn State Summer School, C. C. Dewitt, Michigan School of Technology. G. H. Montillon, University of Minnesota, Advances in Unit Operations. H. L. Olin, State University of Iowa, Advances in Unit Operations. O. R. Sweeney, Iowa State College, Advances in Senior Courses.

4. Civil Engineering: E. L. Waterman, State University of Iowa, presiding. General Topic: Methods of Teaching Civil Engineering Subjects. Opening Remarks: F. M. Dawson, Dean, College of Engineering, State University of Iowa. Surveying: John S .Dodds, Iowa State College. Transportation Engineer: R. B. Kittredge, University of Iowa; L. F. Van Hagan, University of Wisconsin. Structural Engineering: C. J. Posey, University of Iowa; Frank Kerekes, Iowa State College. Sanitary Engineering: Lewis H. Kessler, University of Wisconsin; W. E. Galligan, Iowa State College. A Five-Year Curriculum in Civil Engineering: B. A. Whisler, Iowa State College.

5. Electrical Engineering: M. S. Coover, Iowa State College, presiding. The Place and Content of a Course on "Valuation and Rate Making" in the Electrical Engineering Curriculum. J. M. Bryant, University of Minnesota. Discussors: G. W. Swenson, L. S. Foltz. The Coördination of Mathematics and Physics with Electrical Engineering. H. W. Anderson, Iowa State College. Discussors: L. C. Caverley, L. A. Ware. An Instructor Looks at Teaching. F. A. Maxfield, University of Wisconsin. Discussors: E. W. Kane, R. W. Ahlquist.

6. Engineering Drawing: F. G. Higbee, State University of Iowa, presiding. Fundamentals in Engineering Drawing. An informal presentation of six or seven essential elements by assigned leaders, followed by general discussion. Departmental Inspection.

7. Mechanics and Hydraulics: M. O. Withey, University of Wisconsin, presiding. Desirable Requirements in Engineering Mechanics. G. C. Priester, University of Minnesota. Should There Be a Synthesising Course in Mechanics? J. W. Howe, State University of Iowa. The Relationship of the Junior College to the Work in Mechanics. S. J. Chamberlin, Iowa State College. What Should Be the Place of Soil Mechanics in the Engineering Curriculum? G. J. Tauxe, University of Wisconsin. The Influence

of Coöperative Study on Students of Mechanics. Inspection Tour of Hydraulics Laboratories.

8. Mechanical Engineering: M. P. Cleghorn, Iowa State College, presiding. The Function of Shop and Laboratory Courses in the Mechanical Engineering Curriculum and the Objections to Further Reduction of such Courses, by J. G. Hummel, Iowa State College. Discussion led by P. H. Hyland, University of Wisconsin. In Machine Design, Should We Adhere Strictly to the Design of Individual Parts or Is It Advisable to Make Complete Details and Assembly of an Entire Machine? by John R. DuPriest, University of Minnesota. Discussion led by Thomas G. Caywood, State University of Iowa.

A luncheon and business meeting was held in the Iowa Memorial Union. Address on Explanation and Demonstration of the Thermin Wave by J. G. Saetveit.

BOOK REVIEWS

Static and Dynamic Electricity. WILLIAM R. SMYTHE. McGraw-Hill Book Co., New York. 560 pages. List price $6.00.

This book is planned as a text for a year's course for graduate students who have had a thorough undergraduate training in theoretical physics and the standard courses in differential equations, vector analysis, and advanced calculus. The order of presentation is conventional. It begins with electrostatics to which nearly half of the book is devoted. Besides a discussion of the basic ideas of electrostatics, there is a rather complete discussion of the use of conjugate functions in the solution of two-dimensional problems and spherical harmonics in the solution of three-dimensional problems. The section on electrostatics is followed by a short section on the flow of steady currents in which a number of interesting problems are discussed. In the discussion of magnetism and the magnetic effects of currents, the author follows a procedure which many will regard as commendable in omitting all references to magnetic poles and in using vector potential methods rather than talking about magnetic shells. The discussion of electromagnetic induction is brief but thorough. The next three chapters in the book are devoted to transient phenomena, alternating currents, and eddy currents. A brief chapter on magnetism is followed by a long and comprehensive chapter on electro-magnetic waves and a shorter chapter on special relativity. Only in a final rather brief chapter does the author refer to the atomic interpretations of the electric and magnetic properties of matter.

Some general features of this book which this reviewer regards as commendable are the rigor and completeness of the mathematical development, the large number of solved problems, the large number of problems (over 500) for the student, and the comprehensive bibliographies at the ends of the chapters. The author has apparently devoted some thought to the problem of units. His solution of the problem is to use electrostatic units in the purely electrostatic portion of the book, electromagnetic units in the purely magnetic part of the book, and Gaussion units in the sections on electromagnetic theory. At the bottom of each page the units used on that page are indicated.

Some particular topics, the treatments of which made a favorable impression, are: the capacity of condensers connected in series and the limitations on the ordinary formula; the treatment of the method of images and particularly the discussion of the circumstances under which it is fruitful; the general theorems relating to flow in an extended medium; and the possibility of determinating the ground speed of an aeroplane by measuring the electromotive force induced by its motion relative to the earth's magnetic field. The derivation of Child's equation is the conventional one which assumes that the field intensity at the surface of the wire and the initial velocity of the electrons are both zero without explaining how it is possible under these circumstances for the electrons ever to leave the filament!

The book includes a large amount of material in proportion to the number of pages. This is partly because of the inherent conciseness of the style, but more because the author does not make a practice of treating three or four special problems if all can be regarded as special cases of a single more general problem.

The book devotes considerable space to a discussion of mathematical techniques which are applicable in fields other than electricity and magnetism. For that reason much of the material may in some curricula be included in courses in pure mathematics, or courses labelled "Boundary Value Problems," "Potential Theory," or "Methods of Mathematical Physics."

For the instructor who prefers a thorough mathematical development and for the students who have the mathematical preparation required this should prove an excellent text.

M. F. MANNING

Power Economics for Engineering Students. By R. C. GORHAM. Pittsburgh Printing Company, Pittsburgh, Pa. 310 pages. Price, $3.25.

In the reports of the S. P. E. E. Investigation of Engineering Education the social and the economic content of engineering curricula was emphasized. The engineer needs to develop the capacity to deal with specific economic problems and social situations arising within the realm of engineering. Between economics and the problem of fuel economy there is no such detailed bond of logic as there is between physics and the proper cross-section of a beam.

In the Foreword, Dean Holbrook points out in a pertinent manner that the subject of economics is so important in engineering that special studies in its applied phases of costs and values are necessary. The reviewer agrees with the Dean in believing that no publication could be more timely than one giving the engineering student an understanding of power economics.

Professor Gorham assembled much of the material while teaching junior and senior engineering students at the University of Pittsburgh. During this period he has had the unusual opportunities of being in close touch with outstanding industrial leaders, while at the same time engaging in consulting engineering work.

The author developed his material around a selected group of problems which are intended to illustrate the use of various "yardsticks" in cost comparisons, to show how to recognize the best procedure in the long run, and to help bring the student to the realization of the importance of ultimate economy.

The book is divided into two parts, the first part dealing with the fundamentals of Engineering Economy, and the second showing numerous applications of these principles to public utility problems.

After proceeding to justify the need for economics in engineering, and tracing the history of industrial development in the first two chapters, the author discusses such conventional topics as money's worth, depreciation and obsolescence, and economic life and expansion principles. The economic importance of art and the need for standardization are emphasized. The principles of organization are presented in their proper perspective and an appreciative evaluation of the safety movement is presented. Three common "yardsticks" are presented for making investment decisions. These fundamentals are treated in the first 158 pages of the book, or about one-half of the text.

In the second half of the book, the author discusses the application of engineering economy fundamentals to public utility problems under such stimulating chapter headings as Locating Power Plants and Substations, Modern Generating Stations, Load Forecasting, Valuation, Public Service Rates, Fuel Economics, Load Division, Load Capacity and Service Continuity, etc. Comparable practices in foreign countries are discussed.

The chapter on Development of Automobile Cost Equation should be of immediate interest to all engineering students.

The book is well illustrated with numerical solutions that are worked out in detail. At the end of every chapter are some carefully selected problems, that should prove helpful and stimulating to the student. Many references are listed at the ends of chapters.

In developing the material and in writing the textbook the author was ably assisted by leaders from both the industrial and the educational fields.

The reviewer believes that Professor Gorham has rendered engineering education a real service in preparing a text that should find wide acceptance. The book is well written and neatly printed on a type of paper that should relieve readers of eye-strain. The reviewer will find ample opportunity for using this new text with his own senior electrical engineering students.

A. NAETER